The Antique Wireless Association Review

Volume 26 • 2013

The AWA Review

Volume 26 • 2013

Published by

THE ANTIQUE WIRELESS ASSOCIATION

PO Box 421, Bloomfield, NY 14469-0421

http://www.antiquewireless.org

Devoted to research and documentation of the history of wireless communications.

THE ANTIQUE WIRELESS ASSOCIATION
PO Box 421, Bloomfield, NY 14469-0421
http://www.antiquewireless.org

Founded 1952, Chartered as a non-profit corporation by the State of New York.

The AWA Review

 ISBN 978-0-9890350-0-2

Cover images are of cartons of tubes produced by E.B. Myers in Montreal in 1923-1925, (front cover) and of a tube produced by his factory in Cleveland in 1926, (back cover). Article begins on page 37.

Book design by Fiona Raven, Vancouver, BC, Canada
Printed in Canada by Friesens, Altona, MB

Contents

Volume 26, 2013

Foreword

This year the AWA is celebrating the memory and impact of the Heathkit companies. In 2010 **Erich Bruesche** wrote the definitive Heathkit history in the *AWA Review*, listing all models made from the beginning in 1947 to 1956. At that time he did not have the original model, the O-1 oscilloscope. Well, now he has one, one of two in existence he thinks, and in this volume he lovingly describes it in detail. Erich has done his usual careful and thorough job of describing this instrument. What will he think of next?

Again we are bringing you the *AWA Review* without charge to the membership. This comes as a free benefit to members—your dues are not affected by the distribution of this journal. The *AWA Review* is the AWA's peer reviewed journal. It serves as a historical record where the facts are verified by one or more anonymous reviewers. That gives it some extra credibility as a source of sound reporting of history. The free printing and distribution of this *Review* are again made possible by a generous donation from a long standing AWA member who wishes to remain anonymous. His gift is an indication that he is committed particularly to historical documentation as a key part of our hobby.

This year's volume reflects a number of trends. One is our continuing use of colour. Not many articles on early radio history need colour, but those that do, manage to make excellent use of it. Another trend in the *AWA Review* is the continuing participation by international authors. This year we have an author from Austria.

This year's volume exhibits a great deal of dedication and energy on the part if its authors. The result is a number of fine efforts, the first described above and then the following:

- **Mike Molnar** is a distinguished radio collector and historian. In this issue he chooses to tell about the development of the Neutrodyne circuit, not only as a technical achievement but also as a way for manufacturers to meet market needs while circumventing the restrictions placed on them by RCA. This turns out to be an achievement by an engineering group that spanned many decades and reached into diverse corners of radio and electrical development.

- **Prof. Franz Pichler** has a lively interest in early telegraph instruments and their history. As a part of this interest he has acquired rare pieces of telegraph apparatus. His report this year is not only an account of telegraph history but also a description of how he acquired a rare telegraph sender and restored it to an operable state.

- **Eric Wenaas** has written award-winning articles on important topics in radio

history in this journal and elsewhere. In this volume he takes on the role of Elman B. Myers in early vacuum tube history. Through months of exploration of obscure correspondence Eric brings a new perspective to the impact of Myers' work. He finds that Myers was a skilled tube designer and manufacturer whose flame burned relatively briefly. Myers produced good tubes in unwelcome competition with RCA, and was put out of business mostly by the actions in court of RCA and its associated companies.

- Although last year was the 100th anniversary of the sinking of the *Titanic*, still manuscripts about the event continue to arrive. This year we have a paper by **David and Julia Bart** about the impact of the *Titanic* disaster on maritime safety over the ensuing century. This paper was delivered at the 2012 annual banquet of the Antique Wireless Association and is reproduced for us here. As it turns out, the rate of maritime disasters has been declining, and much of this decline results from lessons learned from the *Titanic*.

- **Bart Lee** is the official historian of the San Francisco Radio Club. As part of his role as historian, he shares with us some details of how the club began and its achievements and activities over the decades. As he reports, it turns out that the SFRC has a long and illustrious history of radio developments and of community service. Who better than Bart to impart this to us in his uniquely appealing style?

- **Richard Brewster** 'was there' during the latter part of television history in the United States. When he wasn't there, he took a lively interest in the documentation of history through reports, interviews and artifacts. In this volume he brings us evidence of the development of broadcast TV by RCA. His enthusiasm is evident in this article, as is his respect for the foresight and courage of David Sarnoff in supporting the project.

- **David Willenborg** regretted the void of information on Robert Lacault, the inventor of the Ultradyne circuit. After literally decades of searching he came up with a description of Lacault's origins, early training, exposure to renowned inventors, and his career writing for Hugo Gernsback. Willenborg was gratified to learn as much as he did after such a long delay, and when you read his account you too will be impressed.

- **Mike Adams** has pursued a hobby of documenting the achievements of West Coast radio and electrical inventors. He does so in such a lively style that his articles and books and TV programs have a wide appeal. Here he has favored us with an account of how Dr. Lee de Forest invented sound movies. De Forest

was probably the radio inventor with the strongest educational preparation in the early decades of the 20th century. Adams speculates on why his inventions did not always reach their full market potential.

Again this year our sincere thanks go to these authors for their fine work. A smoothly finished article often obscures the work that went into writing it, not to mention the time involved.

We continue to use the services of experts in the field as peer reviewers. We believe that this process raises the overall quality of the *AWA Review.* Some of our reviewers have served in this role for a number of years now and deserve our special thanks. The reviewers for this issue are:

David Bart, Julia Bart, Erich Brueschke, Neil Friedman, Gerry O'Hara, John Jenkins, Joe Knight, Virginia Lovelace, Robert Lozier, Tom Perera, Ludwell Sibley, Glenn Trischen, and Eric Wenaas.

This year the Review undertook a project that I felt was long overdue. We invited book designer Fiona Raven to overhaul the design of the publication. What you see before you is the result of her skilled efforts. She has provided new templates for the layout of the material that will now continue in use, hopefully for years to come. We thank Fiona for her contribution.

AWA members and others with an interest in wireless communication history are encouraged to submit manuscripts to the *AWA Review.* A section titled Tips for Authors follows. We try to make the publication effort more collaborative than challenging. The single most important message in this regard is to contact us early if you are considering writing an article.

A cumulative index of Tables of Contents of all previous issues of the AWA Review is maintained on the website of the AWA at http://www.antiquewireless.org.

I have enjoyed receiving and editing your important efforts in historical documentation over the past ten years, the past eight of which have been as your editor. I have decided that now is an appropriate time for me to move on. Manuscripts for future years should be submitted to my successor, whose name will be announced in the *AWA Journal*. Manuscripts sent to me by accident will be forwarded to him. I intend to continue to act in some way in the interest of the *AWA Review.* Thank you to all who have supported me in this role, particularly the authors and reviewers, and our anonymous funder.

Robert P. (Bob) Murray, Ph.D.
Editor
Vancouver, BC, Canada

Tips for Authors

The *AWA Review* welcomes any submitted article on aspects of wireless communications history. In general, shorter articles can be directed to the *AWA Journal* and longer manuscripts to the *AWA Review*. If you are in any doubt about where your article should best appear, please contact one of the editors.

The *AWA Review* will accept and publish Letters to the Editor as space permits. This will be a suitable way to submit your comments if you wish to take issue with a recent article published here, or make other brief comments on wireless history matters. Letters will not be peer reviewed, but will be edited, primarily for length at the discretion of the Editor. The Editor reserves the right to publish responses. Galleys of letters to be published will not be returned to the author. Text is limited to 400 words and no more than 10 references.

For first time authors, articles can be prepared with the help of a more experienced co-author, or the editor can help with the text in the editing process. Members with an interesting story to tell should not be discouraged by a lack of writing experience. The *AWA Review* will accept manuscripts in any clearly prepared writing style. A short style manual produced by the American Radio Relay League is available on request. *The Elements of Style* by William Strunk Jr. and E.B. White is available in most public libraries. Reference material should be cited within the text of the article in any of the accepted reference styles. Reference lists should include all of the sources mentioned in the text. Writers should look at the articles in this volume or in recent previous volumes for examples.

Articles submitted to the *AWA Review* will be laid out on the pages in a style made consistent within the entire publication. Therefore, please do not arrange your illustrations on each page but rather send the text in a file separately from the files for each illustration. This requirement applies equally to the Journal and the Review. (see, for example, "From the Editor" in the *AWA Journal*, April 2006, pages 4 & 5.) Text files can be prepared on any word processing software, but preferably on Microsoft Word. Please do not include idiosyncratic text styles (such as small caps) since these will need to be stripped out when your article is prepared for publication. Illustrations are best sent as .JPG or .TIF files with a resolution of around 300 dpi. JPG files should be Standard (not Progressive). Files can be submitted as e-mail attachments directed to the editor.

The *AWA Review* is making increasing use of color. Color pages come in increments of 32. Recent volumes have had either 32 or 64 color pages. We realize that articles on, say, radio developments from the 1920's do not have a large demand

for color images. If you are considering a paper that contains color images, be sure to contact the editor early to check if all or some of your images can be made to land on color pages. The print shop charges us extra for color pages that are to be printed in black and white. Please realize that black and white images taken with a color camera look to the printer as if they were in color. They need to be converted to greyscale before sending them for printing. Conversion of such images to greyscale is a major consumer of your editor's time.

Manuscripts submitted to the *AWA Review* will be peer reviewed. That is, they will be forwarded to one or more AWA member(s) with expertise in the area of the article. The reviewer's comments will be returned to the author(s) anonymously, so that the reviewer is comfortable with being candid in his or her response. After the reviewers' comments have been addressed by the author, the article will be type set in a publishing software (currently Adobe InDesign), following which galleys will be returned to the author. This will be the last stage at which errors can be corrected. Normally only one set of galleys will be sent.

Articles submitted to the *AWA Review* should be developed in concept not later than early January of the publication year. A first draft should be submitted around March. The editor's deadline for submission of the completed volume to the printer is May 1. Articles not submitted on this schedule will be rescheduled for the next year's volume. For more information contact:

The Editor
The *AWA Review*
address to be announced

Letter to the Editor

The Antique Wireless Association, its members and affiliates, now enjoy an opportunity, and (at least from a historical perspective) face a danger. The archeology of radio beckons, but the sites are disappearing fast.

Archeologists hold that mankind has flourished through three great ages: the Stone Age, the Bronze Age, and the Iron Age. I suggest that we have entered a fourth: the electrical age. We know the artifacts of the electrical age are at risk. But so too are the sites of the great events, and the small events that give texture to our understanding.

Industrial archeology seeks to explore, document and preserve our industrial heritage. The railroad was perhaps the last stage of the Iron Age: the iron horse on steel rails. The telegraph perhaps opened the electrical age: electricity over wires for signals, then for power (and industry), then wireless, radio, television, Radar, computers, the Internet. Historians of technology have documented much of this development. Yet many of the sites are unexplored, undocumented and wasting.

I propose that those of us who can, should take up exploration and documentation of early radio sites. Radio Archeology promises much new knowledge and perhaps some adventure. As it happens, many of the early sites are seaside, adding to their lure. A few have been preserved, for example Marconi's Poldhu, Cornwall, UK transmitter location; a few have succumbed to the elements, for example, Marconi's Cape Cod "CC" station, lost to the encroaching ocean. Archeologists in Ireland are mapping and exploring the Marconi Clifden site. The Marine Radio Historical Society in Bolinas, California has reinstituted the Marconi/RCA marine station KPH/KSM and recently made discoveries about its antenna field and the original KPH site.

Many agencies, companies and organizations would be pleased to help in documenting their or nearby land and its uses. Some have professional archeologists on staff, e.g., the U.S. National Park Service. Many radio journals, perhaps this one, could publish the reports, and encourage further responsible and ethical exploration.

Time is taking its toll. I hope we can use that inevitability to energize the exploration and documentation of the places of radio history.

Very truly yours,

Bart Lee, Fellow of the California Historical Radio Society.
(Correspondence is invited: KV6LEE@gmail.com).

Hazeltine, the Neutrodyne and the Hazeltine Corporation

©2013 Mike Molnar

ABSTRACT

The 90th anniversary of the Neutrodyne patent presents a good opportunity for us to look back at a part of radio history that some may pass over. As the generation of today's radio collector is further removed from the radio engineers that were contemporary with these sets, we can lose the appreciation of what made them special. These radios filled a void in the marketplace in 1923. One can even argue that corporate policy at RCA helped create that void. Louis Alan Hazeltine, and the company he started, did more than answer the call with a new radio circuit. By collecting a talented engineering staff, they would become a powerful force in building the future of radio, television and electronics in the 20th century. This is the legacy of Louis Alan Hazeltine, the Neutrodyne and the Hazeltine Corporation.

Ninety years ago on March 2, 1923, an inventor and a manufacturer brought the model of a new wireless receiver to a meeting of the Radio Club of America. (Fig. 1) While its performance was impressive, what was truly impressive about this inventor's demonstration would not become evident for some time. Louis Alan Hazeltine (Fig. 2) was the engineer-inventor and Joe Freed, an independent manufacturer, had demonstrated the radio that would supersede the regenerative sets of the early 1920's. History will later show this event marked the beginning of an engineering company that helped pioneer modern electronic design and the beginning of an association of

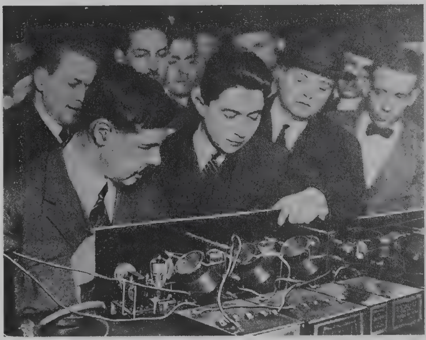


Figure 1. Hazeltine & Freed at the Radio Club of America. *Popular Science Monthly* (July 1923) p.39

Figure 2. Louis Alan Hazeltine in 1923. Booklet-How to build Hazeltine's Neutrodyne Circuit Radio Receiver (1923) p.3. F.A.D. Andrea, Inc. New York

licensed independent manufacturers to produce these radios. The Hazeltine Corporation would go on to play a major role in 1920s and 1930s radio, television, defense work, the introduction of color television and other areas of electronics.

Louis Alan Hazeltine was born in Morristown, New Jersey on August 7, 1886. His family soon moved to Connecticut. After graduating at the top of his high school class, he would return to New Jersey to attend college at Stevens Institute of Technology in Hoboken. Stevens, founded in 1870, is a small but highly regarded engineering and science college on the banks of the Hudson River directly across from Manhattan. Hazeltine graduated with an ME degree in 1906 and was one of few students selected for the General Electric Test Course where he gained valuable experience. In 1907 he returned to Stevens as a teaching assistant in the electrical engineering department. This career choice would not have been a surprise to his family as many of his relatives were in the teaching profession. In 1917 he would be appointed department head. Although his prime interest was mathematics; Hazeltine also became highly interested in the work of Howard Armstrong. Not only had Armstrong patented the regenerative circuit but he also wrote a paper with possibly the first scientific analysis of how the Audion tube worked.[1]

Armstrong's paper inspired Hazeltine to perform a similar analysis of coils and other components. He became convinced that a thorough understanding of all of the wireless components would make improvements in wireless obvious. This resulted in Hazeltine's first published paper. With the help of his lab assistant, Laurence C.F. Horle, he would undertake a study "Losses and Capacity of Multi-Layer Coils". It was presented to the Radio Club of America in February 1917 and published in the April 1917 issue of *QST*. He next presented "Oscillating Audion Circuits" to the Institute of Radio Engineers (IRE) in Sept. 1917 and published it in the Proceedings of the IRE Vol. 6, pp. 63-98. In this work he also introduced the term "mutual conductance" that describes the amplifying property of the triode, and this term was soon adopted by the radio engineering community. Hazeltine would later state that these papers would be the basis of all the work and accomplishments in his career.[2]

The SE 1420

When the U.S. became involved in World War One, the efforts of many individuals, companies and universities were disrupted and they joined in the war effort. At Stevens a "temporary" Navy building was constructed for a program that was to train radio operators and engineers. Hazeltine's assistant L.C.F. Horle left to become the "expert radio aide" for the Navy at the U.S. Navy Yard in Washington under the Bureau of Steam Engineering. In 1918 an order was received to design an improved receiver needed for use on destroyers. The model SE1420 was designated for this unit. When an engineer was needed for this project Horle called on his former professor and Hazeltine travelled to Washington to begin work.

His approach to this project followed what was becoming his trade mark approach: Gain a thorough understanding of all the factors involved and then solve the problem.[3] His two earlier papers on coil design and regeneration would be his guide throughout this work. The specifications for this receiver were a tuning range of 235 to 7500 meters, operating with either a triode detector or by crystal detector if necessary. It had to receive both damped and undamped waves.[4] The receiver had to be sensitive but also selective enough to tune out any unwanted spark signals. Hazeltine fully worked out this design on paper. Then the first model was built and it worked as planned. In his work Hazeltine put great effort into removing all unwanted electromagnetic coupling between components. This required proper coil and component design, proper component location and copper shielding between selected circuits.

A new problem had to be investigated. Spark signals outside the tuned frequency could pass through the capacitive coupling in the triode tube and interfere with the tuned signal. As a solution, Hazeltine worked out a plan to add a reverse coil that would send back a signal to neutralize the unwanted signal. Although it was decided that this was not necessary in the final design, the idea to neutralize the unwanted coupling was a lesson well learned by the professor. The final receiver (Fig. 3) was manufactured for the Navy by Wireless Specialty Apparatus, AMRAD, NESCO and others. Later versions were also manufactured as the model CGR 5-A for the Coast Guard and as the popular IP 501 receiver. The quality of a design can often be measured by its endurance in the marketplace. The SE1420 excelled in performance and was often kept in use for two decades. Professor Hazeltine, soon returned to Stevens where he would teach his methods to his students. Just as Horle brought his professor to the SE 1420 project, many of these new students would go on to be prominent leaders in their professions and many would come back to Hazeltine for consultations or as employees. Some would start companies that would manufacture Hazeltine's inventions.

Figure 3a SE 1420 Receiver (Author's collection)

Broadcasting Begins

After World War One, restrictions on radio for commercial and amateur use were lifted. With this came the birth of transmitting stations that began transmitting music and entertainment over the air waves. Originally transmitted for the purpose of testing equipment, the public soon caught on to the free entertainment coming through the ether. All one had to do was build or buy the radio equipment, find someone

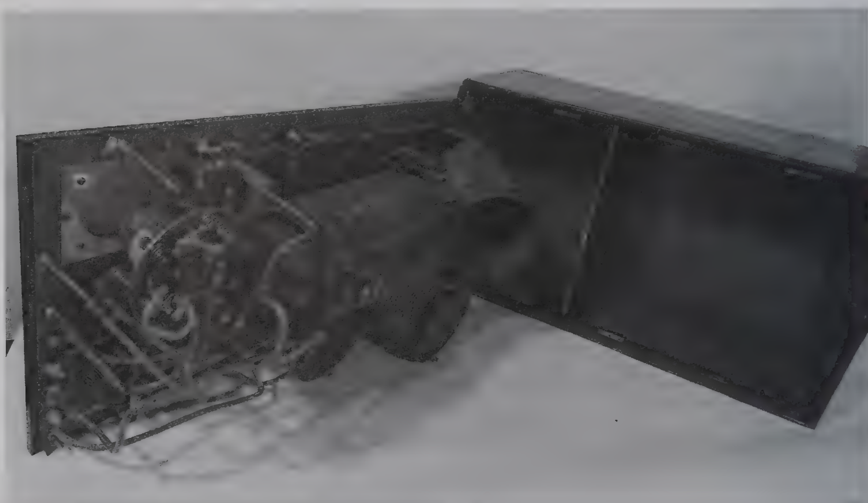


Figure 3b Interior SE 1420 Receiver & shielded compartments (Author's collection)

clever enough to set it up and operate it and you were in! Soon the sounds of the new opera season could be filling your home. Sales of radio equipment boomed. Westinghouse, through RCA, introduced the RA-DA set which exemplifies the design for this first generation of radio sets for the home. Using the Armstrong patent, the circuit consisted of a regenerative detector followed by up to two stages of audio amplification. Several companies manufactured regenerative sets under licenses directly from Armstrong. This patent was sold to Westinghouse who soon added all of their radio patents into the RCA patent pool. No further licenses would be allowed and the existing license holders were kept strictly in line. Other manufacturers who wanted to join in the radio boom found there was no marketable alternative to build a legal receiver without an Armstrong license from RCA. Some of these manufacturers produced crystal sets. These were no longer suitable for most listeners and soon these manufacturers were threatened with legal action.

During this period the regenerative sets that were available were having problems meeting all of the demands of radio listeners. These sets were not user friendly to the casual user. The settings of the different knobs that picked up a favorite station one day were not the same as those that worked the next day. This was referred to as not being able to be "logged". This meant that you could not keep a list of knob settings and use it repeatedly. Also, if the regeneration was not set correctly or if you walked away from the set and it drifted on its own, it would produce loud, irritating squeals. This didn't irritate just the one owner, but these oscillations also radiated from the receiver's antenna and irritated many neighbors using their radios. Publications of the time reported a similar situation to what we've experienced in recent time with computers and currently with cell phones. Mom and Dad would often say "I can't get anything on this thing. I'll wait until one of the kids get home and they can get it going".

There were possible alternatives to the regenerative sets. The superheterodyne circuit was known but not technically ready for mass production and it was also part of the RCA patent pool. Another alternative would be a TRF set (tuned radio frequency). This would have at least two stages of RF amplifiers tuned to the desired wavelength and a detector stage to take the place of the regenerative detector. There were problems with this design caused by the triode tube itself. Capacitive coupling between the elements would cause these sets to squeal as you tried to get the gain high enough for good performance. Other designs without RF amplification couldn't do the job.

Radio broadcasting was expanding around the country. The radio public was ready for a better radio set. Manufacturers were ready to build radios to meet the need. Hazeltine understood the problems with triodes from his experience with the SE1420. He designed and applied for a patent on a set that neutralized this problem.[5]

Hazeltine's patent attorney Willis H. Taylor recognized the need in the marketplace and his firm represented manufacturers looking for a product. Taylor even coined the name for this new product. The day of the "Neutrodyne" had arrived.

Hazeltine and the IRM (Independent Radio Manufacturers, Inc.)

Willis H. Taylor was a student of Professor Hazeltine in the class of 1906. He went on to become a patent attorney in the prestigious New York law firm of Pennie, Davis, Marvin and Edmonds (PDME). While Taylor represented Hazeltine, others in his firm represented a group of radio manufacturers with a patent problem. Wireless Specialty Apparatus Co. who held many patents for crystal radio detectors, had started an advertising campaign stating they would begin enforcing their patent portfolio and warned potential distributors and customers away from buying these sets. For their common defense, these manufacturers banded together to form the IRM. They also hired PDME to represent them. It didn't take long for Taylor and his associates to see the benefit to putting this group and Hazeltine together. Perhaps because they were mostly building crystal sets or perhaps to maintain a standard of quality, the decision was made that the Neutrodyne license would include engineering support. Hazeltine was granted permission at Stevens to rent office space in the Navy Building (Fig. 4) on the Stevens campus. Within a short time Taylor headed the formation of the Hazeltine Corporation to manage the licensing and the engineering services. Licenses were limited to 14 original companies.[6] They all produced a first generation of radios from March 1923 through 1924.(Figs 5a-5c) The companies included:

American Radio & Research Corp. (Amrad)
F.A.D. Andrea (Fada)
Carloyd Electric and Radio Corp. (Malone-Lemmon)
Eagle Radio Corp.
Freed-Eisemann Radio Corp.
Garod Corp.
Radio Service Laboratories, Inc.
Howard Mfg. Co.
Broadcast Mfg. Inc.
Wm. J. Murdock Co.
Stromberg-Carlson Telephone Mfg. Co.
R.E. Thompson Mfg. Co.
Ware Radio Corp.
Workrite Mfg. Co.

Soon Gilfillan Bros. Inc. purchased Radio Service Laboratories (RSL) and after some years the RSL founder,

Figure 4. The Navy Building, Courtesy Stevens Institute of Technology, Samuel C. Williams Library

Figure 5a. F.A.D. Andrea, Inc. (Author's collection), Model 160A, March 1923

Figure 5b. Garod Corporation. (Author's collection), Model RAF, April 1923

Figure 5c. Freed-Eisemann Radio Corp. (Author's collection), Model NR 5, April 1923

to King Quality Products, Inc. who would build the Silvertone Neutrodyne for Sears Roebuck & Co. So, as it turned out, Sears *'takes a big one'* from Gimbels in the department store wars.

Now with the business arrangements made, the race was on to get the Neutrodynes on the market. It was a challenge to have sufficient inventory ready for a boom, but not have warehouses filled with radios during a bust.

The First Neutrodynes 1923-1924

The patent model for the Neutrodyne was a three tube set with two tuned RF stages, a detector, and reflex (loop back) the audio through the two RF tubes to provide two stages of audio gain (Fig. 6). Two of the earlier models manufactured, the Fada 160A and the Garod RAF were 4 tube sets with two stages of RF, a detector and one stage of AF and a second reflexed AF.[7] These were the only reflexed Neutrodyne sets and soon; the Freed-Eisemann NR 5 would set the standard design for the rest of the early Neutrodynes. Five tubes were used two RF stages, a detector stage and two AF stages. There are some likely explanations for the original use of the

Harold M. Lewis, became an engineer at Hazeltine Corp. working on early television development. Broadcast Mfg. Inc. produced one neutrodyne, the Transcontinental ZR1 built for Gimbels Bros. Department Stores. Broadcast Mfg. soon sold their license

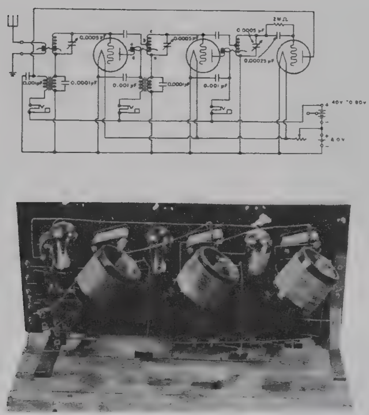


Fig. 8. The original Neutrodyne receiver, as presented to the Smithsonian Museum [20].

Figure 6 Patent model of the original receiver Neutrodyne and Diagram as presented to the Smithsonian Institution. Wheeler, H.A. *Hazeltine the Professor* Greenlawn, N.Y. Hazeltine Corp. 1978 p.42

reflex circuit by Hazeltine. First, when Hazeltine designed the patent model in 1922 the 3 tube configuration was what the radio buyer was accustomed to seeing. Also at this time the price of tubes was still very high and the filament current was 1 amp for each tube requiring frequent battery recharging. The added cost for tubes and battery charging would make the set a harder sale against a three tube regenerative set. By the time these radios were reaching the market, ¼ amp tubes were available and prices of tubes were dropping. Also the reflex circuit had possible patent liabilities. Another feature recognizable in most Neutrodynes was the mounting of the RF coils on the back of the tuning condensers. They were all mounted at the same angle and there is no coupling between the coils. This design was another patented innovation of Hazeltine's. The typical design of the day was to have coils mounted on different axes, vertical, horizontal and front to back. Hazeltine went a step better and devised a formula that calculated what he called the *'critical angle'* of 55.74 Deg.[8] The circuit included the reverse coil and the small "Neutrodon" capacitor (Fig. 7) that connected back to the grid. The first generation of the Neutrodynes started reaching the market in March 1923 with the Fada 160A and soon after, the Garod RAF and Freed-Eisemann NR5.

Hazeltine and Wheeler

The story of the Neutrodyne and the Hazeltine Corp. would not be complete without recognizing the role of Harold Alden Wheeler (1903-1996). Through a number of chance occurrences, Wheeler would have a career with Hazeltine Corp. for over 60 years. Already well known for his radio work, Hazeltine was asked to serve on the

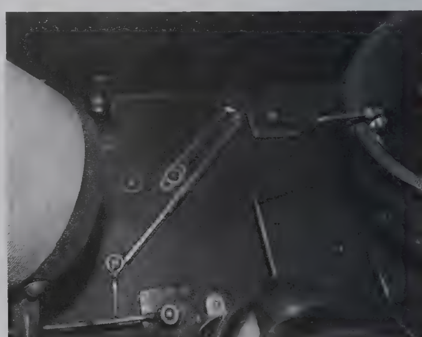


Figure 7. The "Neutrodon" Neutralizing Condenser (center) (Author's collection)

Federal Radio Commission in Washington D.C. Harold Wheeler's father, Archie, in his capacity with the Agriculture Department, also served on the board and met Hazeltine. At this time Harold Wheeler, as a student, was already an avid wireless experimenter and his father discussed this with Hazeltine (Fig. 8). In a later chance meeting in a restaurant in Hoboken both Wheelers were dining when they met Hazeltine. He invited them back to his office at Stevens to discuss radio. At this time Hazeltine and Wheeler discovered that both men were working on the same approach to neutralizing the capacitive coupling in a triode tube used in an RF amplifier. Wheeler then surprised Hazeltine by describing a working model he had built but not yet patented. Hazeltine then surprised Wheeler by telling him that he had applied for a patent two years earlier but had not yet made a working model. Two men working independently on the same solution to the same problem would now form an alliance that would last a lifetime.[9] Eventually a written agreement gave a percentage of the patent royalties to Wheeler. He would complete his education and work summers in radio. Afterwards he would take a leading role with Hazeltine Corp. His many later inventions, including diode AVC, would have a lasting impact on radio, TV and electronics.

Figure 8 Young Harold Wheeler at his radio. Wheeler, H.A. *The Early Days of Wheeler and Hazeltine Corporation-Profiles in Radio and Electronics*. Commack, N.Y.: Hazeltine Corp. 1982 p.106

Many other engineers from the early days of radio would influence Hazeltine and his work. It is also a mark of the professor's impact on his student's that many would come back to him bringing different opportunities. Many would either work for Hazeltine or become licensees. Among those are Harry Dreyer who worked first for Hazeltine and later for Atwater Kent and RCA. Also Paul Ware who would start Ware Radio Corp. and Joe Freed of Freed-Eisemann who worked with Hazeltine on the SE 1420, both saw the benefit of working with the professor. Also joining Hazeltine Corp. was Jack Binns, the radio operator that had celebrity thrust upon him after his courageous work sending the "CQD" emergency signal after the collision of the S.S. Republic in 1909. Knowing he had more to offer than being a celebrity he joined the Hazeltine Corp. as assistant treasurer in 1924. He rose to later become president in 1942 and then chairman of the board in 1952 until his death in 1959.[10]

Second Generation Neutrodynes

The engineers at Hazeltine did not rest after the market success of the first neutrodynes. By 1925, technology was advancing rapidly. There were certain problems related to radio sets that were being addressed. One problem investigated involved uniform gain. As the broadcast band was expanded, the TRF type receivers exhibited a problem of non-uniform gain. Signals of the same strength, at different points of the tuning range would vary considerably. Wheeler built on the work of former Hazeltine student Carl Trube at Thermiodyne to resolve this issue. These listed improvements are characteristic of the second generation Neutrodynes:

- Constant- Ratio transformer design improved gain uniformity across the tune band.
- Antenna coupling RF tubes were added to allow two dial tuning.
- Further development permitted Unicontrol single dial tuning.
- AC tubes were introduced and integrated into the design.
- Shielding was integrated into each set by surrounding each stage.
- Loop antennas were added to some models.[11]

The Freed-Eisemann model 800-C-8 (Fig. 9) is a good example of a second generation Neutrodyne

This period also marked the beginning of a second generation for Hazeltine and Wheeler. Harold Wheeler had finished his education and now worked full time for Hazeltine. Their first offices were at Stevens in that same

Figure 9. Freed-Eisemann Radio Corp (authors collection), Model 800-C-8, April 1923

'temporary' Navy building. Wheeler began a tremendously productive technical period in his career and this was coupled with increased administrative duties. But soon Hazeltine himself retired from teaching and his day to day work at Hazeltine Corp. Hazeltine's first marriage ended and he remarried. He would also drop using Louis as his first name and use Alan instead. He relocated for a time to the west coast and also lived in and toured Europe for two years. He spent some time studying art. Most of his involvement with the company revolved around patent litigation issues.

1926 Patent Litigation

The Neutrodyne patent license was a credible alternative for the IRM members, who were unable to get an RCA license. From the initial introduction it was a successful alternative. In the

1923 line the list prices for Neutrodynes were around $150.00 for a radio that was easier to operate and could outperform RCA Radiola products that had list prices as high as $ 275 for a Radiola IV and $ 350 for a Radiola Grand.[12] This certainly didn't go unnoticed at RCA and they had a weapon in the patent pool that they could use to attack the Neutrodyne and the IRM.

In 1926 RCA brought suit against the Garod Co. claiming infringement on the Rice and Hartley patents. Hazeltine Corp. always believed they were on safe ground against this challenge since only the neutrodyne provided a complete solution to neutralize the capacitive coupling in triodes independent of frequency. The first trial found in favor of Hazeltine. RCA appealed the ruling and won the decision. The resulting situation became complicated. For a manufacturer to provide a Neutrodyne set it would require a Hazeltine license as well as a Rice and Hartley license from RCA. The business situation was considered and Hazeltine Corp. decided to reduce their license fee by one half. This would allow the companies to have the funds to also take an RCA license, which RCA now made available. The Hazeltine license would include their other patents as well as their valuable engineering assistance.

In effect this also caused the end of the IRM since all member companies now held both RCA and Hazeltine licenses. This also freed the Hazeltine Corp. to add new licensees. Among those added in 1927 were Crosley, Grebe, Philco and US Electric Corp. Soon the Neutrodyne circuit would be superseded but the value of the Hazeltine license would be boosted by their engineering services and new innovations were ready for the market.

Screen Grid tubes introduced and the end of the Neutrodyne

In 1928 RCA Radiotron released new vacuum tubes for the market called screen grid tubes. These tubes added a fourth element to the triode. The first model was the Type '22 for DC sets and later the Type '24 for AC use. This element was an additional grid positioned between the control grid and the plate. This allowed the engineers to achieve much higher gain than the earlier triodes. This change, by its nature, also removed the capacitive coupling problem that had created the need for the neutrodyne circuit.

Often when the major patent licensed by a corporation expires or becomes superseded, it will mark the end of the company. This was not the case for the Hazeltine Corp. The other patents held and those coming were still of great value. The rapid changes brought by AC tubes and screen grid tubes also made the engineering services of Hazeltine Corp as valuable as ever. The Neutrodyne however, left a great legacy. During the period of 1923 to 1927 the neutrodyne circuit was licensed for about 1.5 million receivers. Licensees reported a total wholesale price of $ 60 million. This resulted in royalties of $3 million paid to the Hazeltine Corp.[13]

Wheeler, Diode AVC and the Philco 95

The introduction of the screen grid tube and other improvements brought a large increase in the gain available in a TRF set. Early TRF sets have no real volume controls as all of the possible gain was needed to run the set. If a strong local station was tuned in, the operator could remove an AF stage, lower the filament voltage or slightly detune the set for a satisfactory sound level. If tuning a very weak signal, the operator could switch from loud speaker to headphones. Early high end screen grid TRF sets such as Scott, or Norden-Hauck promoted their huge amount of amplification. Unfortunately, when operating these sets even a small amount of drift in signal strength causes an uncomfortable amount of shift in the volume. Also tuning across the dial and different signal levels requires constant volume adjustment.

Harold Wheeler had invented a solution to this problem in 1925, some years before its need in the production radios of that marketplace. In simple form, his Diode AVC Circuit is designed to rectify the RF carrier, develop a bias voltage relative to the incoming signal strength and use that bias back at the RF amplifiers to regulate the gain of the RF section. This had the added benefit of allowing the designer to set that regulated gain to keep the detector input at the best level for a linear response. Wheeler built a model receiver in 1925 (Fig. 10) and also a prototype was built at Stromberg-Carlson. A patent application was made and issued. When Philco became a licensee they used Hazeltine Corp. for engineering. Wheeler was given the task of designing the Philco 95 which was the first commercial set to use his diode AVC. The result was a radio that provided high gain as well as an even volume of sound across the dial.

Wheeler's later refinement was the diode peak detector. This version also provided a method to monitor the bias voltage and use it to measure signal strength. At first this was done with an analog meter but later it was used to also provide the voltage to drive the "magic eye" tuning tubes that became popular on better radios.[14] Wheeler's star was rising and this patent was a valuable addition to the Hazeltine patent pool. When the application for a patent was made, the attorney noted that Wheeler had never been asked to assign patents to the company but Wheeler seeing that his future was secure with Hazeltine Corp. assigned this and his future patents for no financial consideration.

The Depression Era

The depression era hit the radio business as it did most others. Many companies did not survive and leadership changed to companies like Philco who could respond to the demand for lower cost sets. These changes also required changes at Hazeltine Corp. Hazeltine himself came back to Stevens in 1933 and consulted at Hazeltine Corp. and served at times on the board. Under the leadership of William MacDonald moves were made to avoid layoffs.

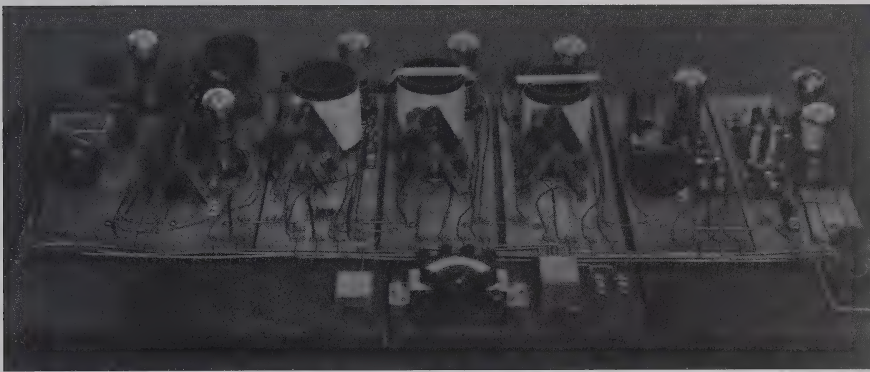


Figure 10. Original Radio with Diode AVC. Wheeler, H.A. *The Early Days of Wheeler and Hazeltine Corporation-Profiles in Radio and Electronics.* Commack, N.Y. Hazeltine Corp. 1982 p.107

Engineers took a 10% pay cut and top management a 25% cut.[15]

To meet the demands of licensees, much work was done to help reduce the cost of building a receiver. Since licensees could now build superhets, experiments were performed to find the best IF frequency. They also worked to reduce the size of the IF coils to fit into smaller cans. Much work was done to reduce the tube count and parts used in the converter of superhets. Also there was demand for engineering of multiband radios and AVC would remain an important source of royalty income.

The final resolution of ongoing litigation would bring needed income to the Hazeltine Corp. The most important of these was a long running suit against Atwater Kent Mfg. Co. The AK radios had an obvious reverse coil in the RF amp but no Neutrodon condenser. Examination found that by placement of components, the AK engineers were able to achieve the small capacity needed to achieve neutralization. When it looked like the courts would agree, a settlement was reached and Atwater Kent paid a back royalty of $680,000.00 and took out a license.[16] The license would be of little value as this would be one more factor in Kent's decision to shut the door to his radio business. But this boost in funding certainly helped the Hazeltine Corp. survive the depression and prepare for some busy times ahead.

Television, Color TV and Defense Work

When a company takes a leadership role in developing a new product like electronic television, work starts long before commercially viable results are achieved. Although not nearly the size of the RCA commitment to TV development, the Hazeltine effort started in 1931. They needed to help their licensees prepare for the shift from radio to TV. They did this in every aspect from determining specifications and standards to building equipment to receive test signals from New York. They were also the only research company outside

of RCA to build their own iconoscope tube and camera to generate their own test images.[17] Much research was done on the development of the needed wideband IF amplifiers and scanning circuits for the magnetic beam deflection needed to produce a reasonable size image.

Soon TV work would be put aside for war work. The Hazeltine Corp. was fully engaged in defense work before the attack on Pearl Harbor. One of their first developments was the SCR-625 mine detector which saw use through the Korean War. They also developed a small television camera to be placed in the nose cone of a bomb for remote guidance. Although a model was made it was not put into use. As we now know it was technology ahead of its time. Another major project that would continue after the war was development of IFF (identification, friend or foe) technology.[18]

After the war, work immediately shifted to color television development. Again this was far ahead of the time color television would be approved and first put on the market in 1953.

Conclusion

Harold Wheeler was awarded 126 U.S. patents in the years from the 1920s through World War Two. After World War Two Wheeler resigned from the Hazeltine Corp. and formed Wheeler Laboratories. This would be an independent company from 1946 to 1959 when Hazeltine Corp. acquired the company. Wheeler served many additional years with Hazeltine Corp. Alan

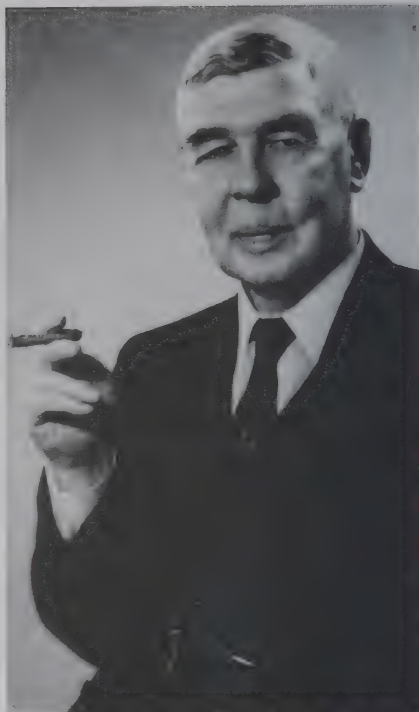


Figure 11 Louis Alan Hazeltine (1886-1964). Courtesy Stevens Institute of Technology, Samuel C. Williams Library

Hazeltine passed away in 1964 at the age of 82 (Fig. 11). He was awarded 36 US patents. They covered an incredible array ranging from Audion tubes to television scanning circuits to a computer for color analysis. In 1968 Wheeler retired from daily work but continued to serve as an advisor, board member and chairman. In 1978 and 1982 he wrote books about his time with Hazeltine and his career in electronics. Wheeler passed away in 1996 (Fig. 12).

The Hazeltine Corp. became involved with defense dept. work for much of the 1980s. They also developed one of the first computer terminals, the Hazeltine 2000. Their defense work

Figure 12 Harold Alden Wheeler (1903-1996) Photo from Wikipedia

specialized in IFF systems (Identification Friend or Foe). In 1986 Emerson Electric Company, also involved in defense work, acquired the Hazeltine Corp. In 1990 Emerson demerged its' defense department and government work, including Hazeltine Corp., to form ESCO Electronics Corp. In 1996 Hazeltine Corp. was acquired from ESCO by GEC-Marconi Electronics Systems Corp. which was renamed GEC-Marconi Hazeltine. At that time the Hazeltine Corp. was valued at $ 110 million. This transaction was reminiscent of concern in the early days of Marconi. Both raised public concern of a defense related US corporation having foreign ownership. In 1999 GEC- Marconi and British Aerospace combined and the Hazeltine part was named BAE Systems, Advanced Systems. In 2002 it was renamed BAE Systems CNIR. After a 2007 reorganization it was renamed BAE Systems, Sensor Systems.[19]

On a personal note, I have been collecting radios since the 1970s. When Radio Manufacturers of the 1920s was published in 1989, it was the first I learned of Hazeltine at Stevens and his offices in the 'temporary' Navy Building. This caused an immediate flashback for me to the early 1970s as a lowly freshman at Stevens and many hours in the still "temporary" Navy Building. Beside my concern that they were as hot or cold in that building as I was, I also found a connection that made me want to find out more about these people and their amazing accomplishments.

References:

1. Hazeltine, Louis Alan. Autobiographical Notes 1924. Printed in, *Hazeltine the Professor.* Hazeltine Corp. Greenlawn, NY 1978 p. 82
2. Hazeltine, Louis Alan. Autobiographical Sketch 1958. Printed in, *Hazeltine the Professor.* Hazeltine Corp. Greenlawn, NY 1978 p. 90
3. May, Myra. From Figures to Fame. *Radio Broadcast* Vol. VII No. 4, August 1925 p.451
4. Instructions for Use of Type SE 1420. Radio Test Shop, U.S. Navy Yard, Washington, D.C. March 1919 p. 8
5. Wheeler, Harold A. *Hazeltine, the Professor.* Hazeltine Corp. Greenlawn, NY 1978 p. 16, 17, 18
6. Douglas, Alan. *Radio Manufacturers of the 1920s Vol. 2.* Vestal Press, Vestal, NY 1989 pp. 1,2
7. Stark, Kimball H. The Neutrodyne

Receiving System. *Radio Broadcast*, Vol. III No. 1 May 1923 p. 41
8. Wheeler, Harold A. *Hazeltine, the Professor.* Hazeltine Corp. Greenlawn, NY 1978 p. 49
9. Wheeler, Harold A. *The Early Days of Wheeler and Hazeltine Corporation – Profiles in Radio and Electronics.* Hazeltine Corp. Commack, NY 1982 p. 73
10. Binns, J. and Lovelace, V.U. Wireless and the Sinking of the Republic, *1909*
The AWA Review Vol. 23 2010 p. 264
11. Wheeler, Harold A. *The Early Days of Wheeler and Hazeltine Corporation – Profiles in Radio and Electronics.* Hazeltine Corp. Commack, NY 1982 pp. 162, 163
12. Wenaas, Eric P. 1923 Radiola Season. *The AWA Review* Vol. 24 2011 p. 116
13. Wheeler, Harold A. *Hazeltine, the Professor.* Hazeltine Corp. Greenlawn, NY 1978 p. 77
14. Wheeler, Harold A. *The Early Days of Wheeler and Hazeltine Corporation -Profiles in Radio and Electronics.* Hazeltine Corp. Commack, NY 1982 p. 230
15. as above p. 129
16. Wheeler, Harold A. *Hazeltine, the Professor.* Hazeltine Corp. Greenlawn, NY 1978 pp. 45, 53, 77
17. Wheeler, Harold A. *The Early Days of Wheeler and Hazeltine Corporation -Profiles in Radio and Electronics.* Hazeltine Corp. Commack, NY 1982 p. 290
18. as above p. 129
19. Hazeltine Corporation History, Wikipedia

Acknowledgement

Much of the information about the IRM members, their radio models and release dates were taken from Alan Douglas's *Radio Manufacturers of the 1920s Vol. 1,2,3.*
Information was taken from too many places in my well-worn copies to list them separately.

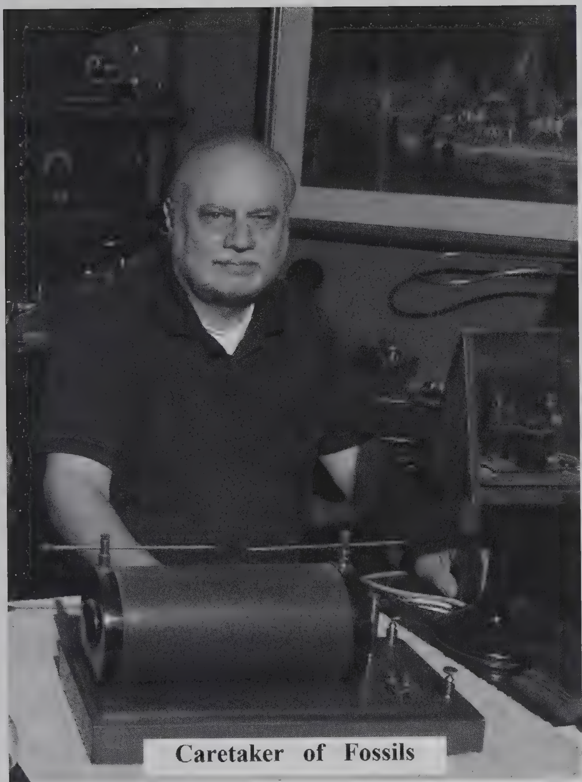
Photo credit

All radio photographs are from the author's collection
These and many more can be seen on his website www.electronicfossil.com

About the Author

After leaving Stevens Institute, **Mike Molnar** decided to fulfill his long time ambition to start his own company. Against the advice of many he started a TV and Electronics business. The advice of the many was right and the business soon ended. Undaunted Mike started another company, Diagnostic Services Inc., in 1983 working with gamma cameras used in nuclear medicine. Still a successful business today Mike designs and builds nuclear medicine systems specifically for veterinary use in both small animal and equine hospitals and universities.

Mike is a long time AWA member and his interest in old radio, television and electronics also continues. His large collection is still growing in his home and available for many to see on the electronicfossil website. With the help of his patient wife Pam, Mike serves as caretaker to the fossils.



Mike Molnar

Magneto-electric Dial Telegraphs

Contributions of Wheatstone, Stoehrer and Siemens

Abstract

A reason for writing this paper was the discovery of a transmitter for a magneto-electric dial telegraph as invented in 1840 by the English scientist Charles Wheatstone. The details of this invention are presented together with the efforts of Cooke and Wheatstone to make their telegraph system known to investors for its use by the public. In addition the later development of dial telegraphs which use a magneto-electric machine to generate the signals for the communicator are covered. A report on the restoration work done on two original Wheatstone magneto-electric communicators for dial telegraphy is given. This paper relies in many parts on the content of the e-book by Steven Roberts[1] and the fundamental paper of John Liffen on the history of the inventions of Cooke and Wheatstone in the field of telegraphy [2]

The needle telegraph of Cooke & Wheatstone in England and the electromagnetic telegraph of Morse in the United States and in continental Europe contributed successfully to the installation of large networks for electrical telegraphy. As we know, both telegraph systems required the use of a telegraph code. In 1840 Wheatstone & Cooke got an English patent for the invention of a "dial telegraph", where the knowledge of a telegraph code was not needed. The letters of the alphabet and the numbers could directly be determined at the sender for their transmission to the receiver, where they could be read. The disadvantage of the "dial telegraph" in comparison to the existing telegraph systems was the low speed of transmission. This paper deals with the invention and the development of a special kind of dial telegraph, the "magneto electric dial telegraph" which uses a magneto electric machine for the generation of the signals. The advantage of this type of dial telegraph was that no galvanic battery was needed for its function.

MAGNETO-INDUCTION TELEGRAPH OF GAUSS-WEBER (1833)

The invention of the first electrical telegraph which was of practical use can be attributed to the German scientists

Gaúss and Weber, both professors at the University of Goettingen. For the communication of scientific data of the magnetic field of the earth they designed in 1833 an electric telegraph, which used the newly discovered effect of magneto-induction (Faraday 1831) for the generation of the transmitted signal. The signals at the sending station were generated by moving a huge permanent magnet up and down in a coil. The receiver was a kind of mirror galvanometer. With a telescope the received signals could be observed by the movment of a light point. Earlier experiments which made use of a galvanic battery had failed.

Feyerabend3 presents the historical

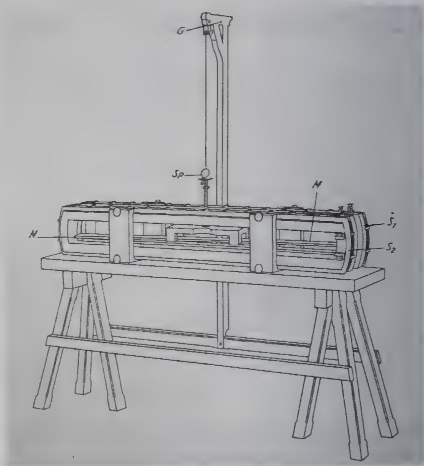


Fig 2: The receiver of the telegraph of Gauss and Weber

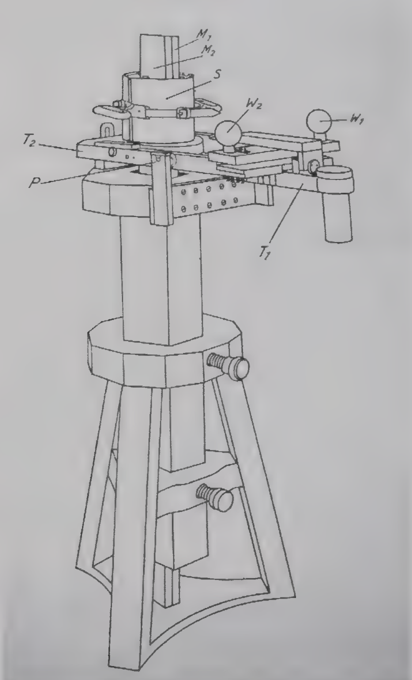


Fig 1: The transmitter of the telegraph of Gauss and Weber

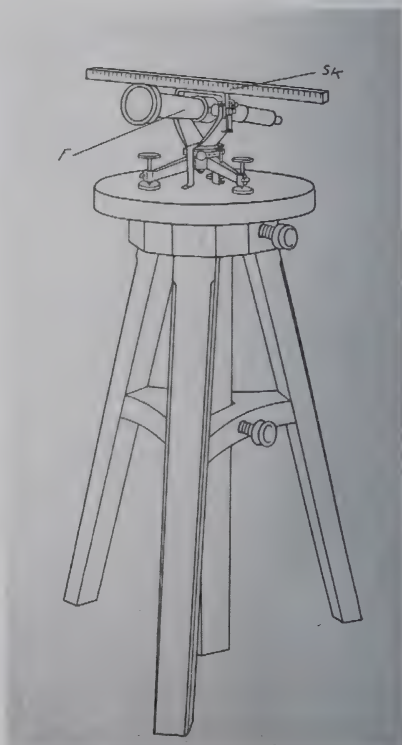


Fig 3: The telescope of the telegraph of Gauss and Weber

facts on the telegraph of Gauss and Weber. The reader may also consult the important book of Shaffner[4] on the history of electrical telegraphy.

THE DIAL-TELEGRAPH OF WHEATSTONE AND COOKE (1840)

The year 1837 brought the invention of the needle telegraph by the English inventors William Fothergill Cooke and Charles Wheatstone followed immediately by the successful implementation of this electric telegraph at different English railways. In 1840 a new patent was added which introduced for the first time the concept of dial telegraphy by electrical currents [5]. The patent covers different inventions of Wheatstone and Cooke. The "mechanical telegraph" of this patent considers a "communicator" which works as follows: By turning a wheel in the form of a capstan a contact gives electrical pulses to the line. The electricity is provided by a galvanic battery. On the periphery of the wheel the different letters of the alphabet and numbers are written. Their location on the wheel determines the related number of pulses to be sent. The original receiver, called the "indicator", of the "mechanical telegraph" consisted of two electromagnets which move a pointer around, when alternatively energized.. This movement is controlled by an escapement. The mechanical force is provided by a weight driven clock work. The "mechanical telegraph" of Wheatstone & Cooke in the original version needed three wires for its function, two wires over land, the third connection could be provided by the ground [6].

The principle of the dial telegraph of this kind can already be found in Halle [7]. There, however, the transmission of the signals is done purely mechanically by turning a metal shaft. It is obvious that such a dial telegraph works only for short distances. On ships, however,

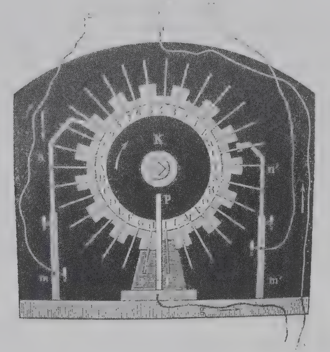


Fig 4 Principle of the "mechanical telegraph" of Wheatstone & Cooke (1840): The communicator.

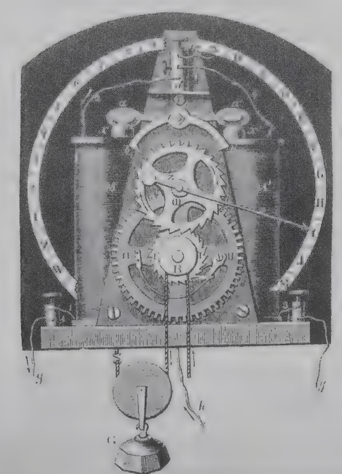


Fig 5 Principle of the "mechanical telegraph" of Wheatstone & Cooke (1840): The indicator.

such telegraphs have found application to give signals from the navigator to the engineer. For the mechanical transmission of the signals not a camshaft but a chain was used. The "mechanical telegraph" of Wheatstone & Cooke did not find an application in England. However in France and Germany dial telegraphs of this kind were extensively used until the appearance of the Morse telegraph. The reader interested in more detail is advised to consult the book by Prescott.[7]

The second concept of a dial telegraph, which can be found in the patent of Wheatstone & Cooke of 1840 deserves our strong interest. It deals with the "electro magnetic telegraph" which uses a magneto-electric machine to generate the pulses of the "communicator". Let us give the original text of the patent for its description:

A magneto electric machine, that may be used in connection with the signal apparatus above described. The current is made to circulate in one direction by means of a inlaid wooden disc on the axis of the armature, in connection with springs in metallic contact with the main wires; the disc is inlaid with two insulated metallic semicircles respectively in connection with each terminal of the armature coil; thus the to- and fro current generated by the machine is driven by a cog-wheel having twelve pins, so disposed that, by the motion of the wheel through a space equal to the distance between them, the armature moves through half a revolution. Twelve signals are thus made without the "communicator", and are all this machine can make with the above described signal apparatus, as its electric current is only of momentary duration, and the electro-magnet cannot act a sufficient time to convey a signal by stopping the pointer.

As we can read, the patent suggests the use of a magneto-electric machine for the generation of the signals of a code-alphabet. In the known models of this "communicator" a battery of five horse shoe magnets give the necessary magnetic field to generate the electrical pulses by induction in turning of a 2-coil armature. This type of construction of a magneto electrical machine was not new in 1840. Already the machine of Clarke of 1835 showed this design. A commutator on the armature wheel converted the AC waves into DC pulses. By a special contact only the peaks of the AC waves are taken. As receiver the "indicator" of the "mechanical telegraph" was taken. In later versions, which needed only two wires for the connection, a receiver with only one electromagnet was used. In its housing this receiver looked similar to a "Schwarzwaelder Kuckucks Uhr"(Cuckoo Clock from the Black Forest), as can be seen by pictures.

The "electro magnetic telegraph" found some application in England as we will discuss later. The little acceptance of dial telegraphy in England in the beginning does, however, not diminish the importance of the invention. The success in later years with the "Universal telegraph" of Wheatstone (1858) in England and the strong acceptance of magneto-electric telegraphs

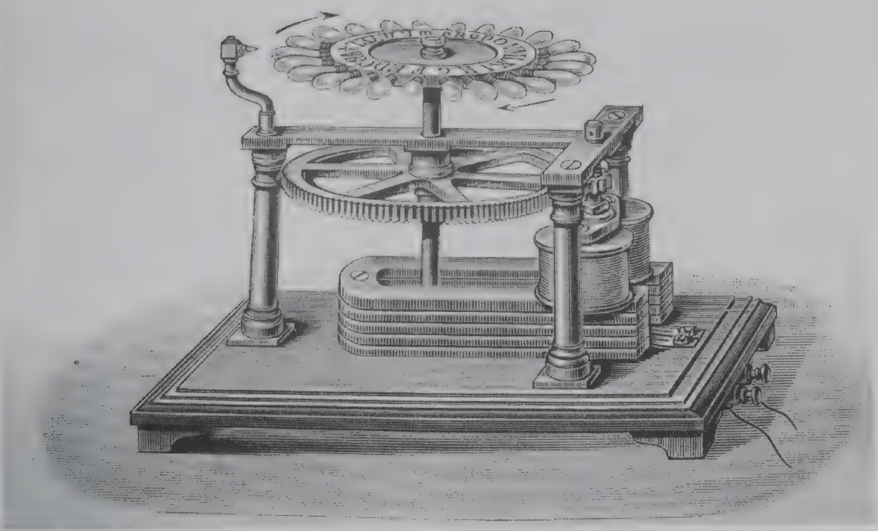


Fig 6: Demonstration the principle of the “communicator” of the “electro magnetic telegraph” of Wheatstone & Cooke, 1840

in Germany by the constructions of Stoehrer (1844) and Siemens (1857) on railways show this.

PUBLIC PRESENTATION OF THE COOKE & WHEATSTONE TELEGRAPHS IN ENGLAND 1843/44

With the success of the installation of needle telegraphs by Cooke & Wheatstone on different English railways the plan arose to interest investors in the erection of a telegraph network for the public. For marketing Cooke engaged Thomas Home, a young man of only 18 years of age. On May 16, 1843 the track of the “Great Western Railway” between London-Paddington and Slough over a distance of 19 miles was chosen to show the function of their own different telegraph systems to possible investors.

Visitors at the Paddington and Slough stations could observe the operation of the 2-needle telegraph of Cooke. This type of telegraph was already in use in different railway systems. In addition the “electro magnetic telegraph”, the sort of dial telegraph which has our interest here, was shown and could be operated. It is reported that Wheatstone presented also his newly invented printing dial telegraph there. The entrance fee to the presentation was 1 shilling and visitors could send and receive telegrams. Probably they were also allowed to operate the magneto electric dial telegraph of Wheatstone. The book of Steven Roberts [8] contains a list of different prominent visitors such as the HRH Prince Albert, the Russian Czar and the king of Prussia. From time to time Charles Wheatstone was present at Paddington and explained for the visitors the function of the instruments. From Gertrud Sullivan, a young lady

THE WONDER of the AGE !!
INSTANTANEOUS COMMUNICATION.

Under the special Patronage of Her Majesty & H.R.H. Prince Albert.

THE GALVANIC AND ELECTRO-MAGNETIC
TELEGRAPHS,
ON THE
GT. WESTERN RAILWAY.

May be seen in constant operation, daily, (Sundays excepted) from 9 till 8, at the
TELEGRAPH OFFICE, LONDON TERMINUS, PADDINGTON
AND TELEGRAPH COTTAGE, SLOUGH STATION.

An Exhibition admitted by its numerous Visitors to be the most interesting and ATTRACTIVE of any in this great Metropolis. In the list of visitors are the illustrious names of several of the Crowned Heads of Europe, and nearly the whole of the Nobility of England.

"This Exhibition, which has so much excited Public attention of late, is well worthy a visit from all who love to see the wonders of science."—MORNING POST

The Electric Telegraph is unlimited in the nature and extent of its communications; by its extraordinary agency a person in London could converse with another at New York, or at any other place however distant, as easily and nearly as rapidly as if both parties were in the same room. Questions proposed by Visitors will be asked by means of this Apparatus, and answers thereto will instantaneously be returned by a person 20 Miles off, who will also, at their request, ring a bell or fire a cannon, in an incredibly short space of time, after the signal for his doing so has been given

The Electric Fluid travels at the rate of 280,000 Miles per Second.

By its powerful agency Murderers have been apprehended, (as in the late case of Tawell,)—Thieves detected: and lastly, which is of no little importance, the timely assistance of Medical aid has been procured in cases which otherwise would have proved fatal.

The great national importance of this wonderful invention is so well known that any further allusion here to its merits would be superfluous

N.B. Despatches sent to and fro with the most confiding secrecy. Messengers in constant attendance, so that communications received by Telegraph, would be forwarded, if required, to any part of London, Windsor, Eton, &c.

ADMISSION ONE SHILLING.

T. HOME, *Licensee.*

Nurton, Printer. 48, Church St. Portman Market.

Fig 7: Promotion of the "electro magnetic telegraph" of Wheatstone at the "Great Western Railway"

Under the Special Patronage of Her Majesty
And H. R. H. Prince Albert
GALVANIC AND MAGNETO
ELECTRIC TELEGRAPH,
GT. WESTERN RAILWAY.

The Public are respectfully informed that this interesting & most extraordinary Apparatus, by which upwards of 50 SIGNALS can be transmitted to a Distance of 280,000 MILES in ONE MINUTE,

May be seen in operation, daily, (Sundays excepted,) from 9 till 8, at the
Telegraph Office, Paddington,
AND TELEGRAPH COTTAGE, SLOUGH.

ADMISSION 1s.

"This Exhibition is well worthy a visit from all who love to see the wonders of science."—MORNING POST.

Despatches instantaneously sent to and fro with the most confiding secrecy. Post Horses and Conveyances of every description may be ordered by the ELECTRIC TELEGRAPH, to be in readiness on the arrival of a Train, at either Paddington or Slough Station.

The Terms for sending a Despatch, ordering Post Horses, &c., only One Shilling.

N.B. Messengers in constant attendance, so that communications received by Telegraph, would be forwarded, if required, to any part of London, Windsor, Eton, &c.

THOMAS HOME, *Licensee.*

G. NURTON, Printer, 48, Church Street, Portman Market.

Fig 8 Presentation of the "electromagnetic telegraph" for Prince Albert

of London society exists a diary where the following text can be read

"We were taken into a small room, where were several wooden cases, containing different sorts of telegraphs"

and

"In one sort every word was spelt, and as each letter was placed in turn in a particular position, the machinery caused the electric fluid to run down the line, where it made the letter show itself at Slough, by what machinery he (Wheatstone) could not undertake to explain. After each word came a sign from Slough, signifying 'I understand' coming certainly in less than one second from the end of the word"

BREAK THROUGH OF THE ELECTRIC TELEGRAPH IN ENGLAND

In May 1845 Cooke could report to the English press that under his leadership the following railways were using his electric telegraph [9]

- London & South-Western Railway- for the government, from the Admirality at Whitehall to Portsmouth, 90 miles
- London & South Western Railway- for commercial use, Nine Elms to Southhampton, 77 miles
- London & South Western Railway- for commercial use, Southhampton to Gosport, 21 miles
- London & Dover (South Eastern Railway)- Tunbridge to Maidstone (single line), 15 miles

- London & Croydon Railway, 9 miles
- South Devon Railway - Exeter to Plymouth, 52 miles
- London & Blackwall Railway (cable), 3 miles
- Great Western Railway - London to Slough, 18 miles
- Yarmouth & Norwich Railway (single line), 20 miles

In most of the cases Cooke's 2- needle telegraph was used. The magneto electrical dial telegraph of Wheatstone continued to be only in experimental use. To promote its application on April 10, 1845 a competition in chess was arranged between the chess-champions of the time Howard Stanton and Hugh Alexander Kennedy, who stayed in the telegraph station in Gosport and six chess-amateur players on the other side 90 miles away in Vauxhall. The play started at 11:30 a.m. and got finished at 7 p.m.. After altogether 43 moves the play ended undecided. The magneto electrical dial telegraph which was used proved to be not reliable enough. Without having the assistance of Professor Wheatstone the play finally had to be finished by the use of the 2-needle telegraph of Cooke[10].

SUCCESSFUL APPLICATIONS OF MAGNETO ELECTRIC TELEGRAPHY

Charles Wheatstone sold his telegraphy patents in 1843 to Cooke. However he kept the rights for the countries in continental Europe with exception of Austria and Russia. A partial success in the application of the dial telegraph in the version of the "mechanical telegraph" of the 1840 patent was reached in the Netherlands. There on May 25, 1845, the installation for the railway of the "Hollandsche Ijzeren Spoorweg-maatschappij", the Holland Iron Railway Company, was finished. The work and the maintenance were done by the instrument maker Eduard Wenckebach from Amsterdam. An installation of the magneto electrical dial telegraph,

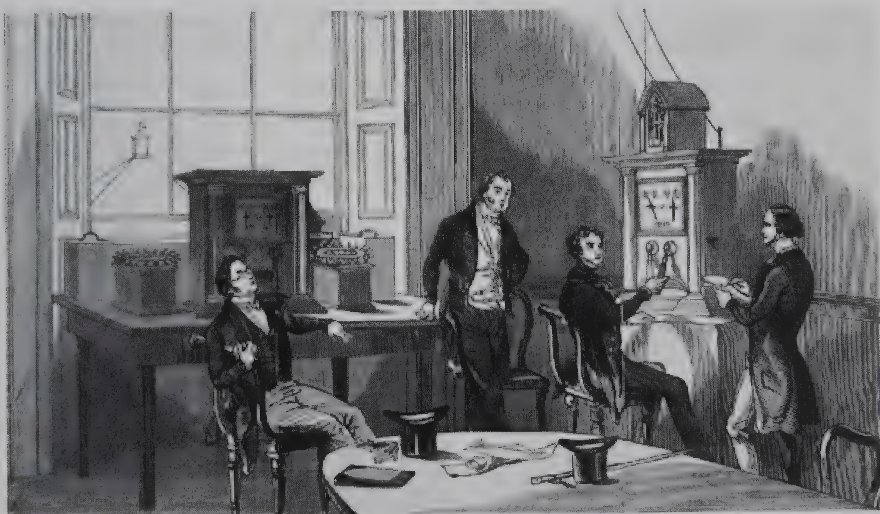


Fig 9 Nine Elms Telegraph station, 1847

the "electro magnetic telegraph" of the patent of 1840, was completed by Wheatstone between Paris and Versailles in 1845 and stayed in operation until 1850[11].

A great success for dial telegraphs, especially for the version "mechanical telegraph" of the patent of Wheatstone & Cooke of 1840 was achieved in later years in France and Germany. In France the instrument makers Breguet and Froment , in Germany Fardely, Siemens and Kramer were the most important manufacturers of dial telegraphs. They needed for their operation the use of a galvanic battery. The reader interested in greater detail is advised to consult the books of Karras[12] or the already mentioned book of Prescott. In general it can be stated that the concept of the dial telegraph finally found great interest. In the book of Zetsche[13], which is fundamental for the history of electrical telegraphy, all together 28 chapters are devoted to that topic. All this proves that the idea of Wheatstone to design a electrical telegraph which allows the user to operate it by writing the telegraphic message directly using the normal alphabet was fruitful. As we know, this idea was later taken up again by the printing telegraphs of Hughes and House and in our time by the teleprinter. In the following chapter we discuss the further development of the magneto electric dial telegraph as invented by Charles Wheatstone in 1840 with his "electro magnetic telegraph".

FURTHER DEVELOPMENT OF THE MAGNETO ELECTRIC DIAL TELEGRAPH

The magneto electric dial telegraph of the patent of Wheatstone & Cooke of 1840 did not find practical acceptance. The main reason maybe was the low speed of the magneto electric machine. Later inventions and designs of Wheatstone in England and Stoehrer and Siemens in Germany brought improvements and finally success.

The "Universal telegraph" of Charles Wheatstone (1858)

Charles Wheatstone, since 1834 Professor of Experimental Philosophy at King's College in London, kept his interest in his "electro magnetic telegraph" alive, even considering its low success in the past. He still pursued the plan to establish a telegraph network for the public which could easily be operated by people. To reach this goal he constructed the "Universal telegraph" which was patented in 1858. Let us discuss briefly in what way Wheatstone was able to improve his "electro magnetic telegraph" of 1840 by this new invention. While the design of the magneto electric machine in 1840 used a pair of coils for the armature, the new design of 1858 had four coils which were mounted on two batteries of horse shoe magnets. The armature was created by turning a piece of soft iron. In later versions of the "ABC telegraph" of the General Post Office also the Siemens armature came into use. An early description of the "Universal telegraph" can be found in the Journal of the "Deutsch- Oesterreichische Telegraphen-Verein" of the year 1864[14].

The marketing of the patent was given by Wheatstone to the "Universal Private Telegraph Company". Within a short time important cities in England got a telegraph network using this telegraph. Besides the police and other governmental institutions which were interested, many private companies such as for example the news agency Reuter got connected. After 10 years of successful operation the "Universal Private Telegraph Company" came under control of the British Government. The responsibility for operation and maintenance of the whole network was transferred to the "General Post Office". From this time on the "Universal telegraph" was called the "ABC telegraph". The book of Steven Roberts devotes a whole chapter to the "Universal telegraph" and the "Universal Private Telegraph Company"[15].

The Dial telegraph of Emil Stoehrer (1846)[16]

Emil Stoehrer was born in 1813 near Leipzig, Germany. After school he was an apprentice with the mechanic and instrument maker Johann Gottlieb Wiessner in Leipzig. Married to the daughter of Wiessner he was later the owner of the shop. Already from 1844 on Stoehrer made experiments with magneto electric machines. Their construction was similar to the machine of the American mechanic Joseph Saxton of 1835. From 1846 on Stoehrer used his machines for the construction of a magneto·electric dial telegraph. He sold in 1846 such telegraphs to the private line from Bremen to Bremerhaven and

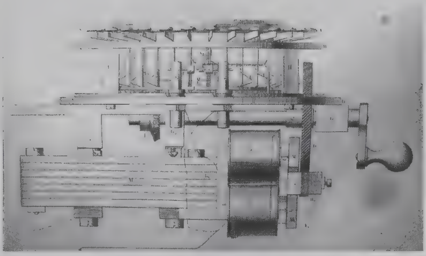


Fig 10: Universal telegraph of Charles Wheatstone: the communicator

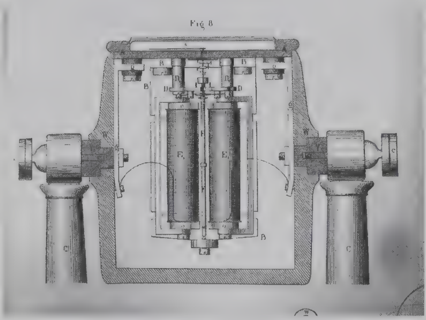


Fig 11: Universal telegraph of Charles Wheatstone: the indicator

Fig 12: ABC telegraph of the General Post Office

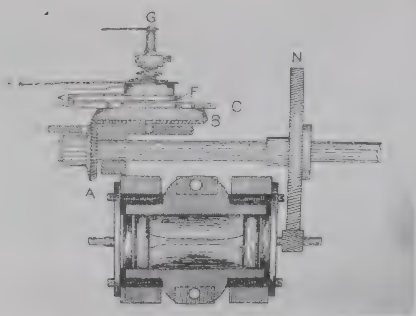


Fig 13: magneto electric machine of the ABC telegraph with Siemens armature

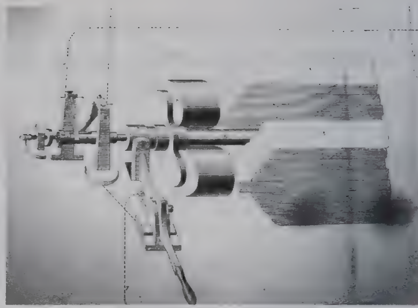


Fig 14: Dial telegraph of Emil Stoehrer (1846): the communicator

in 1847 for the railway from Leipzig to Altenburg in Saxonia. In 1850 Stoehrer provided the Bavarian railways with his telegraph where they stayed in operation until 1857.

The "Magnetzeiger" of Werner von Siemens (1857)

Werner von Siemens was one of the most important scientists, engineers and inventors of the 19th century in Germany. Besides his technical and scientific skills he was also a talented businessman. He founded the company Siemens & Halske in Berlin, a company which exists today as the "Siemens Corporation". Already in 1848 he contributed his "selfacting dial galvanic telegraph" to the art of telegraphy. In 1856 Siemens got a patent for his "double-T-armature" an important improvement for the construction of effective magneto electric machines. Early applications of the new construction were found in railway signalling and in mining for magneto electric exploders. But Siemens, having knowledge of the inventions of Wheatstone, very soon

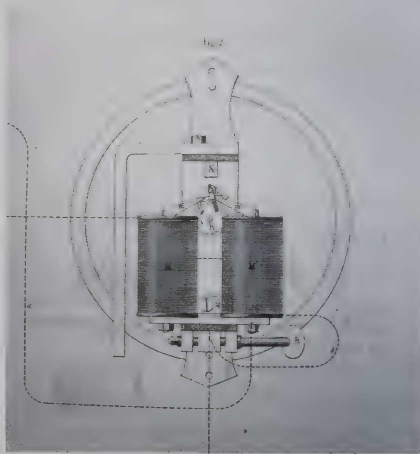


Fig 15: Dial telegraph of Emil Stoehrer (1846): the indicator

used his improved magneto electric machine for the construction of a dial telegraph, his "Magnetzeiger" of 1857. In 1857 the Bavarian railways bought the new dial telegraph of Siemens, replacing the dial telegraph of Stoehrer. For the rest of the 19th century the Bavarian railways used Siemens dial telegraphs of this kind. The company Siemens & Halske was also successful in selling their magneto electric telegraph, the

"Magnetzeiger", to other countries, such as Sweden, Russia and Turkey. The author of this paper has in his collection a Siemens "Magnetzeiger" from Sweden from about the year 1860. Its huge wooden case of pine with a little door at the front to allow a look at the magneto system gave a visitor the idea to compare it with a "Hundehütte", a dog-house, a comparison which can not be accepted for this existing wonderful historical piece. A documentation of the introduction of the telegraph in Sweden, where also this dial telegraph, in Swedish language called "Visartelegraf", is covered by the book of Tahvanainen[17].

Fig 16 Magnetzeiger of Siemens & Halske 1857,

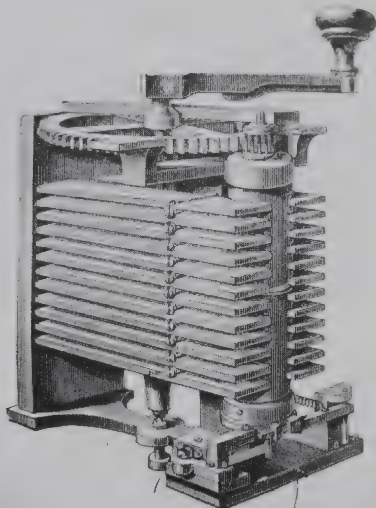


Fig. 17 Magneto Electric Machine with Double-T-Armature

Restoration of two Wheatstone transmitters

Two original Wheatstone dial magneto transmitters were found on ebay. They can be dated as manufactured in the 1840´s and meet the description as given by Wheatstone in his patent of 1840. Both were incomplete and restoration work was needed. In addition I have tried to find out from which place they came. The two were originally identical. Both, let's call them "Wheatstone 1" and "Wheatstone 2" had missing parts and needed some wood repair. "Wheatstone 1" was nearly complete; only the gear wheel of the armature anchor was missing. The dial wheel of "Wheatstone 1" shows 11 letters and the cross symbol (+), which defines the initial position. The letters are (counter clock-wise): B,D,F,H,K,M,O,R,T,W, and Z, each associated with a stick for turning the dial wheel. The dial wheel shows

the engraving "C. *Wheatstone Inv.*" We observe that from the full alphabet every second letter is missing. A dial wheel having only 11 letters to operate suggests that the telegraph was used together with a code book. The missing gear wheel of the device "Wheatstone 1" has been replaced and the function is now satisfying. At the second magneto transmitter "Wheatstone 2", both the dial wheel with its gear wheel and also the gear wheel of the armature anchor were missing. Regarding the origin of the two Wheatstone transmitters the following guess can be made. Both transmitters might have been originally in the possession of the former British Telecom Museum in London. When this museum was closed in 2006, most of the items were sold by a special auction. Some of them which seemed not to be so attractive, might have been sold extra as a duplicate or discarded. Both Wheatstone transmitters might have been a part of this auction. The following pictures of "Wheatstone 1" compare it before and after some restoration work

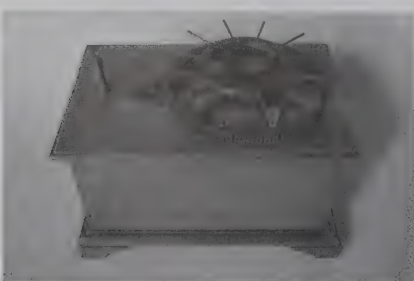


Fig 18 "Wheatstone 1" as received

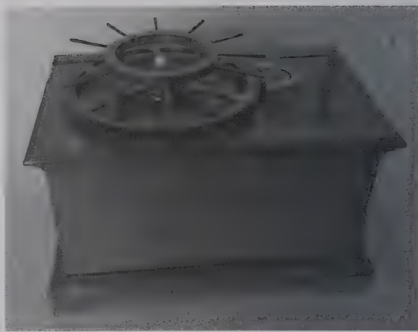


Fig 19. "Wheatstone 1" complete

"Wheatstone 2" has a missing gear wheel and is also missing a dial gear wheel. The seller did not know that it was an incomplete Wheatstone magneto transmitter and it was sold as a "dynamo-electric machine". After restoration it will have a dial gear wheel which has the full alphabet of 23 letters, such that it can be operated for normal writing. The restoration work should be started soon and should be finished by July 2013.

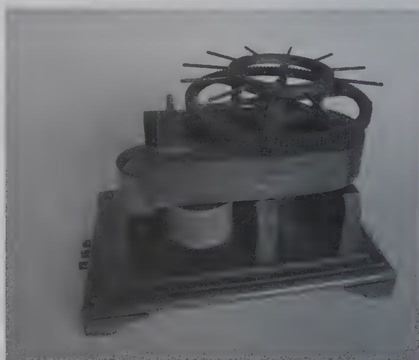


Fig 20 "Wheatstone 1" open, original

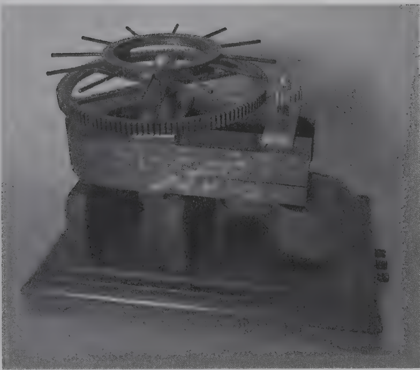


Fig 21 "Wheatstone 1" open complete

SUMMARY

This paper tries to present the invention and development of the magneto electric dial telegraph as invented in 1840 by the famous British scientist and inventor Charles Wheatstone. The main reason for writing this paper was the discovery of an original communicator of the "electro magnetic telegraph" of Wheatstone in the version as described in the patent of 1840. Such types of communicators and the related indicators were used to advertise the telegraphs of Cooke & Wheatstone in 1843/44 to interest investors in establishing a public telegraph network. Although magneto electric dial telegraphs did not achieve a similar importance in England compared to the needle telegraph of Cooke & Wheatstone, and the telegraph of Morse in the U.S.A. and in continental Europe, they nevertheless represent an important part of the his tory of the electric telegraph

ACKNOWLEDGEMENT

Many thanks go to Steven Roberts, London, for his help and provision of literature and pictures. John Liffen, Curator for Telecommunication, Science Museum London, made a search in the depots for pieces of magneto-dial telegraphs from the Wheatstone Collection of King's College and provided pictures which have been very helpful for the restauration work. From Bill Burns, New York, I received valuable information on the British Telecom Auction of 2006 which may help to identify the found Wheatstone Communicators. The machine shop of Gerald Paschinger helped to replace the missing gears and in manufacturing for the second com-

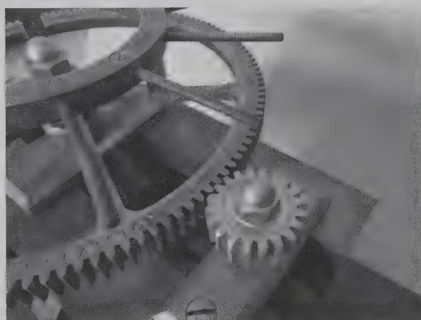


Fig 22 "Close-up of gear"

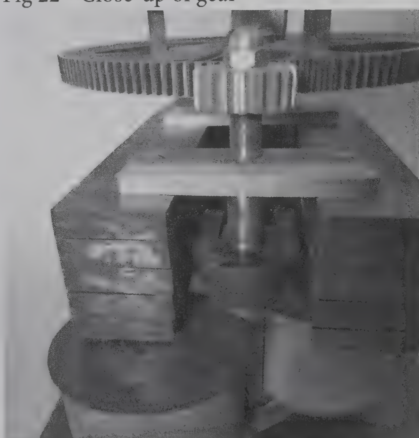


Fig 23. "Close-up of commutator and coils"

municator the capstan wheel with the full alphabet.

REFERENCE NOTES

[1] Steven Roberts: *Distant Writing.* © 2006-2012, electronic book available by <distantwriting.co.uk>

[2] John Liffen: The Introduction of the Electric Telegraph in Britain, a Reappraisal of the Work of Cooke and Wheatstone. *Int. J. for the History of Eng. & Tech.*, Vol 80, No.2, July 2010, pp. 268- 299.

[3] E.Feyerabend: *Der Telegraph von Gauß und Weber im Werden der elektrischen Telegraphie.* Reichspostministerium, Berlin 1933

[4] Tal P. Shaffner: *The Telegraph Manual.* New York 1859

[5] Wheatstone, Charles and Cooke, William Fothergill: Improvements of giving signals and sounding alarm at distant places by means of electrical currents, AD 1840, January 21, Patent No 8345

[6] Johann Samuel Halle: Magie, oder die Zauberkräfte der Natur, Zweyter Teil, Berlin 1784, VII, pp. 141- 145.

[7] George B. Prescott: *Electricity and the Electric Telegraph.* Fourth Edition, New York 1881

[8] Steven Roberts: *Distant Writing.* E-book ©Steven Roberts 2006- 2012

[9] Steven Roberts: *Distant Writing* p. 12

[10] for a detailed discussion we again refer to the book of Steven Roberts on "*Distant Writing*", pp. 11,12.

[11] for details we refer again to "*Distant Writing*" pp. 13,14 and 120.

[12] Th. Karras: *Geschichte der Telegraphie.* Braunschweig 1909

[13] Karl Eduard Zetsche: *Geschichte der Elektrischen Telegraphie*, Berlin 1877

[14] Zeitschrift des deutsch-oesterreichischen Telegraphen.Vereins, Jg. XI, (1864), pp. 64- 71

[15] Steven Roberts: *Distant Writing*, chapter 4, pp. 120- 152.

[16] we follow *Zetsche: Geschichte der Elektrischen Telegraphie*, Berlin 1877, pp. 250- 254.

[17] K.V. Tahvanainen: *Telegrafboken. Den Elektriska Telegrafen I Sverige* 1853- 1996, Telemuseum Stockholm, 1997.

PHOTO CREDITS

Fig 1-3: E.Feyerabend: Der Telegraph von Gauß und Weber im Werden der elektrischen Telegraphie. Reichspostministerium, Berlin 1933

Fig 4-5: George B. Prescott: Electricity and the Electric Telegraph. Fourth Edition, New York 1881

Fig 6: Th. Karras: Geschichte der Telegraphie. Braunschweig 1909

Fig 7: by courtesy of Steven Roberts

Fig 8: by courtesy of Steven Roberts

Fig 9: by courtesy of Steven Roberts

Fig 10: Zeitschrift des deutsch-oesterreichischen Telegraphen Vereins,Jg. XI, (1864), Heft 3,4 und 5, Fig. 1 and Fig. 8

Fig 11: Th. Karras: Geschichte der Telegraphie. Braunschweig 1909

Fig 12: T.E. Herbert: Telegraphy, London 1906, chapter XI, p.357

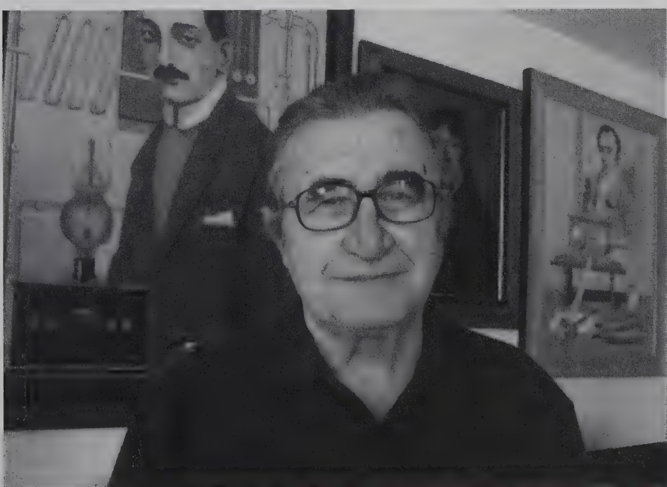
Fig 13: Zeitschrift des deutsch-oesterreichischen Telegraphen Vereins, Jg. II, (1855) , Bl. XIX

Fig 14: George B. Prescott: Electricity and the Electric Telegraph. Fourth Edition, New York 1881

Figs 18-23: author

ABOUT THE AUTHOR

Franz Pichler was, during 1950-54, an apprentice telephone technician at the "Fernmelde-Monteur-Schule" in Graz, Austria and was excited to build crystal sets and radios. Later he studied mathematics and physics at the University of Innsbruck, Austria, where he received the degree Dr.phil. in 1967. During his visit in 1982/83 to the State University of New York at Binghamton, he bought at an auction in Vestal N.Y. a US battery radio of the twenties which he restored to operation and showed to his students. Jim Spalik, an AWA member, took him to the spring meet in Holcomb in 1983 and to the AWA museum there where he got bitten by the radio bug. Since then he has collected books, radios and telegraph equipment. Ilse, his wife, allows him to display his collection all over the home. Since 2004 he has retired as an Emeritus professor (Systems Theory) of the Johannes Kepler University of Linz, Austria and he enjoys writing papers and books dealing with the history of electricity and information technology. He is a member of AWA, TCA and the Austrian club "Freunde der Mittelwelle" (friends of AM radio).



Franz Pichler

Part II: Elman B. Myers and the Vacuum-Tube Tangle

Abstract

This article is the second in a series dealing with the tangled web of conflicting patent rights associated with the Fleming valve and the DeForest audion that resulted in numerous imbroglios among and between the Radio Corporation of America (RCA), DeForest, and infringers who threatened the patent rights of RCA, DeForest, and DeForest patent assignees AT&T and Western Electric. The first article appearing in the 2012 edition of *The AWA Review* focused on the role of Elmer T. Cunningham in the vacuum-tube tangle,[1] while this article focuses on the role of Elman B. Myers (see Fig. 1).

Overview

Elman Myers gained notoriety as a quasi-legitimate tube manufacturer by designing and marketing a high-performance tubular audion immediately following World War I. He was the driving force behind two U.S. companies, the Radio Lamp Corporation incorporated on Nov. 19, 1918,[2] and its successor company, Radio Audion Company, incorporated on Sept. 3, 1920.[3] Myers designed a three-element audion for Radio Lamp that was later manufactured and distributed by Radio Audion under the trade name RAC-3 (see Fig. 2). After protracted litigation in 1922, first with RCA and immediately thereafter with AT&T, the RAC-3 was found by the courts to infringe on DeForest patents, and Radio Audion was soon forced into receivership. Myers then moved to Montreal, Canada where he was the driving force for a new Canadian company, E. B. Myers Co. Ltd., which ultimately manufactured and marketed the same basic tubular audion in three versions, the Universal, the Dry battery, and the Hi-Mu. This company was relocated to Cleveland, Ohio in late 1925 after

Fig. 1. Elman B. Myers as he appeared in 1932. (*Electronics*, Nov. 1932, p. 347)

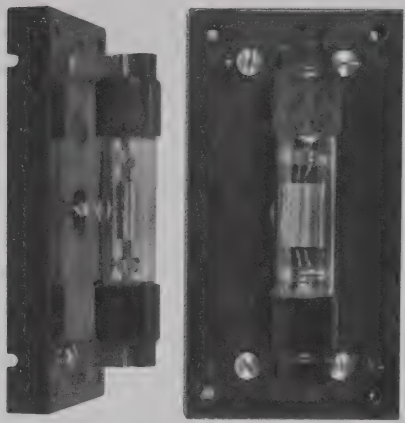


Fig. 2. Myers designed a three-element tube and tube holder for Radio Lamp Corp. that was later manufactured and distributed by Radio Audion Co. under the trade name RAC-3.

the last of the relevant DeForest audion patents expired on Feb. 18, 1925. The move was accomplished by assigning the assets of the Canadian Company to a new U.S. company, the Myers Radio Company—later renamed the Myers Radio Tube Corporation. While Myers was not associated with the latter company, it had the right to use the Myers name. It was only a few months after ads began to appear for Myers Radio Tube Corporation that General Electric sued them on April 15, 1926, alleging that the Company was infringing on the Langmuir reissue patent No. 15,278 entitled "Electron Discharge Apparatus." Ads abruptly disappeared from radio magazines after June of 1926, and soon thereafter the Company went into receivership and ceased operations.

The litigation involving Radio Audion, DeForest, RCA and AT&T between 1921 and 1925 was arguably the most interesting that resulted from the vacuum-tube tangle in the postwar period. This litigation exposed the underlying weakness in RCA's legal position as it attempted to enforce it patent rights under the Fleming patent, and it underscored the reason why RCA elected to settle its patent infringement litigation with Elmer Cunningham rather than go to trial after it failed to obtain a preliminary injunction to prevent Cunningham from marketing his AudioTron tube. The litigation produced five judicial opinions documented in the *Federal Reporter*—four from the District Court in Delaware and one from the Third Circuit Court of Appeals. One of these opinions (281 Fed. 200) was precedent setting,[4] and has often been cited in litigation in cases involving contributory infringement caused by two or more parties acting in concert.

[While Lee de Forest preferred the spelling "de Forest" for his name, he generally used the spelling "DeForest" in conjunction with his companies. For simplicity we will adopt the latter spelling throughout this article. *Ed.*]

Myers' Prewar and Wartime Employment

Although Myers' prewar participation in the tube tangle was covered in Part I, his employment history immediately before, during and immediately after WWI is crucial to the story related here. Much of what is known about Myers' employment history during this crucial period comes from his testimony at the

FTC hearings in 1927,[5] which unfortunately was confusing and contradictory. Consequently, Myers' work history will be addressed here in some detail beginning with his employment by the DeForest Company in California in early 1915, at which time he was working with Otis Moorhead at a booth at the World's Exposition of San Francisco. Inaccuracies in the dates and periods of employment cited by Myers in his testimony are identified and corrected in the following paragraphs.

Not long after the fair opened on Feb. 20, 1915, both Myers and Moorhead left the employ of DeForest, and with the aid of former General Electric glass blower, Ralph Hyde, designed an audion tube, which generally became known in the trade as the Electron Relay. No sooner had Myers and Moorhead begun to market the tube than DeForest filed suit against Myers in San Francisco in mid-1915 for infringing on his audion patents. Rather than answering the complaint in California, Myers voluntarily left the West Coast and reentered the employ of DeForest in New York. Absent any response by Myers to the complaint, an interlocutory (temporary) decree was entered against Myers on Dec. 16, 1915 prohibiting him from making or marketing audions. Myers was ordered to reimburse DeForest for damages, but DeForest did not ask for an accounting, nor did he pursue the matter further.

Upon returning to New York, Myers immediately began work on a new tubular audion for DeForest similar to the one he developed for Otis Moorhead on the West Coast. The new Type T tubular audion he designed for DeForest first appeared in ads in April 1916. It was no surprise, then, that the DeForest audion was very close to the Moorhead audion in both appearance and function.

In December of 1916, DeForest sent Myers to Marconi's Belmar high-power station in New Jersey to obtain evidence that Marconi was infringing on the DeForest audion patent by using three-element valves in their commercial work.[6] He broke into the facility and took several three-element valves that he found there. He then proceeded to sign an affidavit on behalf of DeForest, attesting under oath to the break-in at the Belmar facility and to the discovery and removal of the three-element tubes. When DeForest later submitted the deposition during the course of ongoing litigation with Marconi over infringement of the Fleming patent, the Marconi Company promptly filed a criminal complaint against Myers for breaking/entering and theft. Myers was indicted by the grand jury of Monmouth County in New Jersey, arrested in New York on April 25, 1917 where he was held without bail pending extradition, and eventually returned to New Jersey to stand trial in the jurisdiction where the crime occurred.

Myers would have received a stiff sentence for this crime had DeForest not intervened on his behalf with the Navy Department, who in turn pressured Edward Nally, vice president of American Marconi, not to press the case against Myers. Here is how Nally

recalled the incident in testimony before a congressional committee on the Government Control of Radio Communication in 1919:[7] "The DeForest Co. sent this employee [Myers] to break into our high-power station, which he did, to steal some of our valves, which he did, and he was indicted and would have been detached from the DeForest employ for some period if it had not been for Capt. Hooper and others of the Navy Department, who personally requested me not to push the case, because this man Myer[s] was needed in connection with some Government work, the DeForest people having said so." Marconi's house organ *The Wireless Age* reported in the September 1917 issue that Myers had pleaded "non vult" (a type of plea that can be entered by a defendant who is unwilling to admit guilt but is willing to submit to the court for sentencing), fined $500 plus costs, and placed on probation for one year.[8]

How long Myers remained at the DeForest Company after this incident is not known for certain. Elman Myers in later life prepared a resumé of his work history from 1905 to 1966, but there is virtually no detail covering the period from 1917 to 1919.[9] The only known chronology of Myers' activities from time he left the DeForest Company to the end of WWI appears in testimony given by Myers on Nov. 29, 1927 at hearings held by the Federal Trade Commission (FTC) on the alleged radio monopoly by RCA, et. al.[10] In his testimony, Myers stated that he remained with DeForest until the early part of 1918, and then went to work for General Electric in Harrison, New Jersey where he worked on "development engineering, principally on radio tubes" for "about a year." Myers was then asked, "After you left the employ of the General Electric Company which I think you said was in 1919, what did you do?" (The questioning examiner had calculated from Myers' previous testimony that he was at General Electric until the early part of 1919.) Myers replied, "I entered the employ of the Western Electric Company." Myers' response clearly leaves the impression that he began work at Western Electric in 1919, but that is in direct conflict with his later testimony that places him as an employee of Western Electric in New York City working on tube production during the war for most of 1918: "I was employed by the Western Electric Company as an expert on tube manufacture and I took charge of their production and shrinkage at the time I went into their employ. At the time I went into their employ they were making 150 tubes per day. I was with them seven months and by the introduction of efficient methods in shrinking tubes and modern methods of manufacture we were at the end of that time turning out tubes at the rate of 5,700 tubes per day."[11]

By all accounts, Western Electric was making approximately 200 tubes a day in the tube shop at 463 West Street in New York City for use in the telephone system when the U.S. entered the war in July of 1917.[12] Within six months of entering the war, Western Electric

had modified its type "J" and "E" tubes to meet military requirements, and in early 1918 transferred production of the tubes with the Army's designation VT-1 and VT-2 and the navy designation CW-933 and CW-931 to the Western Electric Hawthorne Works just outside of Chicago, IL. These accounts go on to say that production rates for military versions of these tubes at Western Electric reached about 25,000 per week by the armistice in November 1918. So, if Myers entered the employ of Western Electric when tube production was at 150 tubes per day as he said, and if he contributed to the dramatic increase in tube production to 5,700 tubes per day as he said, he must have been employed at Western Electric no later than early 1918 when tube production for the military first started—not 1919 after the armistice—and he must have remained there for at least seven months—that is, until the end of the war. It should be noted that Myers made essentially the same claim to an interviewer from *Radio News* in 1922: "When the war came on and our boys on the other side were in need of Radio Equipment, the Western Electric Company called on Mr. Myers to take charge of production of "J" tubes. He raised the output of the plant from 150 to 5,000 tubes per day in seven months."[13]

Assuming that Myers' testimony about being employed by GE after leaving the DeForest Company is accurate, then Myers must have begun work at GE no earlier than late July or early August 1917—immediately following his trial for breaking and entering into the Belmar Station while employed with DeForest—and he could not have stayed at GE any longer than early 1918, the time he must have entered employment at Western Electric where he was known to have worked on tube production during the war at the Western Electric building located at 463 West Street in New York City (see Fig. 3).[14] This chronology is consistent with all known facts, and is similar to what Myers stated in his testimony—with the notable exceptions that each of the three career changes to which he referred must have been taken place at least six months earlier than he recalled, and the period of employment at GE must have been closer to six or seven months, rather than a year as he recalled.

Fig. 3. Elman Myers worked at the Western Electric building located at 463 West Street in New York City during the later part of WWI.

Radio Lamp Corporation Formed

Whether Myers left Western Electric on his own at the time of the armistice on Nov. 11, 1918, or was laid off with a large number of others workers contributing to the war effort immediately following the armistice is not known. What is clear, however, is that Myers and five other individuals formed the Radio Lamp Corporation one week after the armistice with the following purpose stated on the Certificate of Incorporation filed with the State of New York on Nov. 18, 1918: "To manufacture, buy, use, sell and deal in lamps for transmitting and receiving radio, and lamps of every description; also to manufacture buy, use, sell and deal in all articles to which the same may be applied or which may be necessary or convenient in connection therewith."

There were six names that appeared on the certificate identifying the shareholders of this closely held corporation: George E. Ruppert, Alfred B. Simonds, William Burckhardt, Elman B. Myers, William Pelzer, and George A. Ganong. George Ruppert, an attorney and financier who was in the business of incorporating companies on behalf of clients in New York City, served as the President of Radio Lamp. Alfred Simmons and William Burckhardt were associates of Ruppert who also participated in the incorporation of Radio Lamp. The names W. Burkhardt, A. B. Simmons and W. Ruppert often appeared together with the business address 5 West 86th St., Manhattan in notices of incorporation such as the one published in "New Incorporations" section of The New York Times for the Radio Lamp Corporation.[15]

Elman Myers was chief scientist in charge of developing a new type of tubular audion and the only one with a background in designing and manufacturing tubes. William Pelzer, an attorney specializing in corporate law and patent litigation, served as the business manager and corporate attorney for Radio Lamp. Nothing is known about George Ganong; apparently he was a passive investor.

The filing date of the incorporation papers—exactly one week after the armistice—indicates that a substantial amount of planning must have taken place prior to the armistice. Myers must have decided to go into the business of manufacturing and marketing three-element tubes well before the armistice—perhaps while he was still an employee of Western Electric. The timing of the filing, so close to the armistice, may have been no coincidence; the principals may have been waiting for the armistice to file, knowing the non-military market would not open up until after the war ended.

Perhaps the most interesting information in the incorporation papers was the small amount of working capital available for tube development. One thousand shares of common stock with a par value of $5 were authorized for a total capital value of $5,000. Twenty shares were issued to each of the six individuals listed above in return for $5 per share, which produced $600 of working capital. The incorporation papers explicitly stated that this was

the totality of the company's initial working capital: "the amount of capital with which said corporation will begin business is SIX HUNDRED DOLLARS ($600.)." This small amount would have been barely sufficient to pay Myers' salary for the first six months, much less to provide sufficient capital for renting factory space, purchasing manufacturing equipment and raw materials for tubes, and hiring a staff to operate a factory.

Myers must have been the only paid employee, and his activities must have been confined to the design and development of a new prototype audion tube. Assuming he was paid the average salary for a wage earner in New York City in 1918, reported to be $1556 per year or $130 per month for electrical engineers,[16] the initial capitalization of $600 would have only been enough to pay Myers' salary for little more than 4 months. An additional $1,900 in operating capital was raised later by selling another 380 shares of authorized stock to the existing shareholders, which, with the original $600, might have carried Myers for 19 months (from December 1918 to June 1920). With this limited capital, Myers could have designed and made a few prototype tubes working out of his home, but he certainly could not have rented factory space and set up a manufacturing line.

There is no record of any activities of the Radio Lamp Corp. for the first twelve months following its incorporation on Nov. 18, 1918. Then on Nov. 25, 1919, George Ruppert, president of Radio Lamp Corporation, signed an agreement with the DeForest Radio Telephone, and Telegraph Co., which was purported to be a license from the DeForest Company permitting Radio Lamp to manufacture three-element audions covered by DeForest patents.[17] Like the terms of the agreement Cunningham signed with DeForest on behalf of his AudioTron Co., DeForest agreed to not to sue Radio Lamp for infringement in return for royalties on each tube sold, but the agreement could not prevent Western Electric from suing.[18] Also, like the Cunningham agreement, the fact that Western Electric had been given the right to sue in the patent assignment by the DeForest Co. in 1917 was not recited in this agreement.

The Radio Lamp agreement was different from the Cunningham agreement in several respects. Both agreements required a royalty payment for each tube sold, but the Cunningham agreement required only $0.80 per tube regardless of retail price, while the Radio Lamp agreement required a payment of $1.00 or 20% of the retail price per tube, which ever was greater. Since the retail price of the Myers tube was never more than $5.00, the royalty amounted to $1.00 per tube. Both agreements required minimum monthly payments, but the Cunningham agreement required minimum monthly payments of $800 from the date of the agreement, while the required minimum monthly payments of $3,000 per month for Radio Lamp was deferred to December of 1922—two years after the date of the agreement.

The Radio Lamp agreement had another clause at the end of the agreement (Paragraph 16) that required it to manufacture and sell a minimum of 6,000 tubes over each six-month period beginning six months after signing the agreement. If Radio Lamp failed to do so, except for conditions that would prevent the normal operation of its factory, DeForest at its option could cancel the agreement. This clause was later waived by DeForest for reasons unknown.

Since both of these agreements were dated Nov. 25, 1919 and both were executed within days of each other, the reason for the significant differences in these terms can be most easily explained by the difference in the production status at the two companies. Cunningham was manufacturing and selling between 900 to 1,100 tubes per month in December 1919,[19] just enough to cover his minimum royalty requirements, while the Radio Lamp Corp. was not yet manufacturing tubes in quantity, if at all. Radio Lamp needed time to finish tube development, set up a production line and generate sales of at least 3,000 tubes per month to cover the minimum royalty requirement of $3,000—hence the two-year deferment of the minimum requirement.

If Radio Lamp was not yet manufacturing tubes in quantity by November of 1919, then why did the company bother getting a royalty agreement at that time with DeForest? The answer is that Radio Lamp had developed a prototype tube by then and was about to test market it by selling a small number of sample tubes made by Myers in his laboratory. Myers testified that because of the injunction issued against him previously in the litigation with DeForest in 1915, the Company "didn't dare to operate without a license from him [DeForest]".[20] Radio Lamp's business manager, William Pelzer, stated in an affidavit that he was concerned about the injunction that DeForest had against Myers, upon which DeForest could bring contempt proceedings against the company: "That the DeForest Company holding an injunction against Mr. Myers, who was our chief engineer, would also be in a position, and probably would, bring contempt proceedings to punish Mr. Myers for contempt of the said injunction should he continue to serve in the capacity of chief engineer, supervising the manufacture of our audions."[21]

Ironically, the interlocutory decree entered against Myers on Dec. 15, 1915 as a result of DeForest's suit had been dismissed for lack of prosecution because DeForest decided to drop the matter after Myers returned to the employ of DeForest in New York. According to correspondence from a law firm in San Francisco to Sheffield & Betts dated July 23, 1921, an order with the Court there was made and filed on Dec. 6, 1915 withdrawing the application for permanent injunction.[22] Apparently Myers, Radio Lamp and RCA were unaware of this fact until RCA discovered it in the course of later litigation against Radio Audion. DeForest must have been the only one who was aware of this fact,

and clearly it was not in his best interest to reveal it.

RCA Takes Note of Radio Lamp Activities

It was not long after Radio Lamp started selling samples of its tubes in early 1920 that RCA took notice and immediately requested its attorneys to send Radio Lamp Corp. a letter to cease and desist manufacturing and selling it three-element tubes. Sheffield & Betts prepared drafts of two identical letters addressed separately to Elman Myers and Radio Lamp Corporation dated May 4, 1920, which stated in part:

"We are informed that you are offering for sale, and selling vacuum valves or tubes for radio work which are not licensed under the Fleming patent [No. 803,684], but which are an infringement of the 1st and 37th claims thereof.... Therefore, on behalf of our client you are hereby notified that you are liable to a suit for an injunction and for profits and damages for your past infringements.... We demand that you immediately cease such infringement and that your make suitable compensation to our client for your past acts of infringement."[23]

It is interesting to note that both draft letters had the names of the intended recipients in the usual place at the top left corner of the letter, followed immediately by Verona, New Jersey—but without any street address, as if the drafter of the letter did not know the addresses of either the Radio Lamp Corporation or Elman Myers.[24] RCA attorneys almost certainly would have searched for the addresses of Radio Lamp Corp. and Elman Myers in the incorporation papers, but they would have found that there was no address listed for the Corporation—only a statement that "Its principal business office is to be located in the Borough of Manhattan in the city of New York." They also would have found the address of Elman Myers listed as 62 Personette Street, Verona, New Jersey. Not having any better address for the Corporation, it is likely that the attorneys planned to send both letters to the Verona address of Elman Myers. However, there is no record of whether these two draft letters were actually sent, and if they were sent, there is no record of where they were sent—nor is there any evidence that either recipient responded to these letters.

For reasons detailed later, it is highly unlikely that Radio Lamp Corp. was in a position to rent factory space or mass-produce tubes by May 1920, the date appearing on these letters. Moreover, Verona was a bedroom community at that time, lacking the support system needed for a manufacturing facility.[25] It is much more likely that Elman Myers, who lived at the Verona, NJ address appearing on the incorporation papers, had a laboratory in his garage or basement there where he was developing a tube for the Radio Lamp Corp. This assertion is supported by a statement made in an article appearing in *Popular Radio* by J. C. Gorman following an interview in 1922 with Elman Myers: "Mr. Myers has done important research work in the largest laboratories

Fig. 4. That Myers' address of 62 Personette Street, Verona NJ listed in the Radio Lamp Corp. incorporation papers was not a factory can be confirmed by this aerial photograph of his house (see arrow) and the surrounding residential neighborhood.

throughout the country. In the development work during the war he was in the foremost ranks. Since the war he has been at work on the tube in his own laboratories, ever improving and perfecting it..."[26]

That Myers' address of 62 Personette Street, Verona, New Jersey appearing in the Radio Lamp Corp. incorporation papers was not a factory is confirmed by the aerial photograph of the residential neighborhood surrounding his house site, which is indicated by the arrow in Fig. 4. While the house currently located at 62 Personette St. was built in 1949, many of the houses in this neighborhood—including several appearing in this photograph—were built well before the incorporation of the Radio Lamp Corporation in 1918. For example, the house located two doors away at 66 Personette St. was built in 1901. Clearly, there was no factory in this neighborhood at the time Myers lived there circa 1918-22.

Several months after drafts of the cease-and-desist letters were prepared, RCA engaged Eugene Pearl, a salesman of radio apparatus and resident of New Jersey, to investigate the tube situation at Radio Lamp, and to report his findings to RCA's attorneys, Sheffield & Betts. Sheffield & Betts memorialized Mr. Pearl's findings in a letter to RCA attorney Ira J. Adams dated June 18, 1920.[27] The letter stated that Mr. Pearl discovered Radio Lamp had sold a few tubes to amateurs and a few tubes to the Adams Morgan Company in New Jersey, but "only for the purpose of proving they could be sold at a certain price." In the end, Adams Morgan refused to handle the tube. Mr. Pearl also reported that he visited the Radio Lamp factory in New Jersey and obtained some information on what they were doing, but could not get competent evidence that the company was manufacturing the tube or selling it commercially. It is more likely that Mr. Pearl actually visited the home of Elman Myers and saw his laboratory, where at that time he would have been making prototypes. It is no surprise Mr. Pearl could not get "competent evidence" that Radio Lamp was manufacturing tubes. In the end, Sheffield & Betts encouraged RCA to obtain "competent evidence that the company is manufacturing the tube and selling it commercially" before taking any further action.

Radio Lamp clearly became aware of RCA's interest in their activities either by receiving the demand letters that RCA may have sent in May 1920, or through the inquiries of RCA agents such as Mr. Pearl in May and June. In

either case, RCA's interest in the activities of Radio Lamp Corp. was not lost on its officers. They recognized that RCA might take legal against them at some point in the future—certainly by the time they began to manufacture and market inexpensive tubes on a scale large enough to make inroads on RCA sales. Being a New York corporation, they realized that if RCA were to sue them at some point in the future, it would be in the New York Circuit Court where RCA had enjoyed huge successes in litigation with DeForest and others over infringements of the Fleming valve. To escape this jurisdiction, the officers of Radio Lamp decided to create a new company with a new name, incorporate it in Delaware, and locate its facilities in New Jersey. RCA would then have to sue the new entity in either in the Circuit Court of New Jersey where the alleged infringements for manufacturing and sales would take place, or in the Circuit Court of Delaware, the state in which they were contemplating incorporation. Neither the Circuit Court of New Jersey nor of Delaware would be compelled to follow past decisions of the Circuit Court of New York for infringements of the Fleming valve patent by tubes when used as amplifiers or oscillators.

Activities of the Radio Audion Company

A Certificate of Incorporation for the Radio Audion Company dated Sept. 3, 1920 was filed in Delaware by its agent, Corporation Service Co. of Wilmington. The certificate listed only three individuals as shareholders: C. T. Cohee, C. B. Outten, and S. L. Mackey. The total authorized stock of the Corporation was listed in the certificate as 500 shares, and the notice of incorporation in *The New York Times* on Sept. 6, 1920 listed the capitalization at $50,000. There was no reference to any of the principals of the Radio Lamp Corp. in the certificate, but it is known that that the officers and directors of both companies were the same and that Myers was the chief engineer of both.

With $50,000 in new capitalization, Radio Audion could now afford to rent space for a new factory, purchase the necessary manufacturing equipment, and hire personnel to staff operations.

Fig. 5. The very first ad placed by Radio Audion for its "Universal Audion" at the low price of $3.50 in a national magazine appeared in the December 1920 issue of *Science and Invention* magazine.

Radio Audion rented factory space located at 90 Oakland Avenue in Jersey City, NJ beginning in September of 1920.[28] The Company must have spent the next few months developing the assembly line to manufacture audions because the very first ad for its new tube with the trade name "Universal Audion" did not appear until the December 1920 issue of Gernsback's new *Science and Invention* magazine—and at the low price of only $3.50 (see Fig. 5).[29] It is important to note that the "RAC-3" designation for the Radio Audion tube did not appear anywhere in this ad, indicating that the designation RAC-3 used later as the trade name for the tube had not been selected as of December 1920.

Just as the ad appeared in the magazine, the original five shareholders of Radio Lamp attended a shareholder meeting on Nov. 29, 1920, at which time they voted to dissolve the Radio Lamp Corp. The timing of this dissolution suggests that the officers of the new Radio Audion Co., a Delaware Corporation, feared that the December advertisement might precipitate a suit by RCA, and they wanted to preclude the possibility of being sued by RCA in the New York District Court as Radio Lamp, a New York Corporation.

When RCA learned of the Radio Audion advertisement appearing in the December 1920 issue of *Science and Invention* magazine, it immediately became alarmed that this tube, which was advertised at the low price of $3.50, would make serious inroads in their plans unless they were stopped. Cunningham, who had just become an RCA distributor in June 1920, wrote RCA complaining about the competition of infringers in general and Radio Audion in particular. In that letter, Cunningham reminded RCA that DeForest almost put him out of business by threatening suit against the technical press for selling his tubes that DeForest had asserted were infringing on his patents, and suggested that RCA now follow the same course. RCA followed Cunningham's advice by immediately notifying Gernsback, owner of *Science and Invention*, that the magazine was advertising infringing tubes and threatening litigation. The ads immediately ceased, and no other Radio Audion ads have been found in any Gernsback publication since that time.

RCA correspondence during this period reveals RCA executives had taken note that Radio Audion had stopped advertising after December 1920, and that Radio Audion was not interfering with RCA business in tube sales. However, RCA was still concerned that Radio Audion might be making tubes in quantity and stockpiling them so that they could dump a large number tubes on the market in a short period of time in the future. RCA was again advised by its attorneys at Sheffield & Betts to gather intelligence on Radio Audion and attempt to purchase one of their tubes in the market place before taking any legal action.

Radio Audion continued to manufacture and sell tubes throughout the first quarter of 1921 without benefit of

advertising in any national radio magazines, and as a result, RCA seemed to be unaware of Radio Audion activities. Later correspondence between Darby & Darby and RCA would reveal that Radio Audion had been selling its tubes to the U.S. government during early 1921, transactions that could have easily escaped notice by RCA. However, it was not long before RCA with its extensive spy network found that Radio Audion was also manufacturing and marketing tubes designated "Universal Audion RAC-3" to the public.

RCA instructed attorneys Sheffield & Betts to send a letter to Radio Audion similar to the one they prepared for Radio Lamp in May of 1920, this time notifying Radio Audion that its RAC-3 was infringing not only the Fleming patent, but also the DeForest patents to which RCA had obtained a license under the Western Electric agreement in June 1920. William Pelzer of Radio Audion promptly acknowledged RCA's letter dated April 19, 1921 with a letter of his own dated April 25, 1921 stating that Radio Audion had no desire to infringe patent rights of others, and that he would refer the matter to its attorney for a legal opinion.

Immediately after receiving this letter, RCA began to explore the possibility that DeForest might be convinced to cancel the December 1919 indemnity agreement he made with Radio Audion based on violations of certain terms in the contract, thereby avoiding litigation with Radio Audion altogether over infringements of either the DeForest or Fleming patents. After receiving a copy of the agreement from DeForest's attorneys, Darby & Darby, RCA focused on Paragraph 16 of the agreement, which specified that the agreement could be cancelled if 6,000 tubes had not been manufactured and sold by December 1920. RCA through its spy network had established that Radio Audion could not have sold anywhere near 6,000 tubes by that date. RCA wrote AT&T a letter dated April 27th asking AT&T to contact DeForest through his attorneys, Darby & Darby, requesting that DeForest cancel the indemnity agreement with Radio Audion based on Paragraph 16. DeForest responded that, while he wished to be helpful, he had already waived that clause orally at the request of Radio Audion.

RCA also noticed that there was no provision in the original DeForest–Radio Lamp agreement that permitted an assignment to any other entity including Radio Audion. At RCA's request, AT&T again contacted DeForest through Darby & Darby to see if the agreement with Radio Audion could be cancelled based on an invalid assignment. Once again, DeForest responded by saying that he had already orally approved the assignment. DeForest was then asked to unilaterally cancel the agreement, a request he refused for fear of litigation from Radio Audion. In the end, AT&T attorney George Folk wrote Sheffield & Betts on May 27, 1921 stating that RCA's redress would have to be a suit against the Radio Audion Company for infringement under the under the Fleming and DeForest patents.

Even before RCA received a

respónse from Radio Audion to its letter notifying them of infringement and requesting they cease and desist, RCA received a good indication of Radio Audion's position from an unexpected source—none other Elman Myers himself. It so happened that RCA employee H. C. Gawler attended a banquet of the North New Jersey Radio Association on May 10th in Newark, NJ where Myers made a presentation of his work on development of the RAC-3 tube. Gawler met with Myers after the banquet and obtained much useful information on the RAC-3 tube as well as Radio Audion's position on the patent situation, which he dutifully documented in a memo sent to E. E. Bucher of RCA dated May 11, 1921.[30] In the memo he wrote: "1) that he [Myers] had manufactured the sample tube shown us, 2) that the tubes were in use in thirty-eight states, 3) that his Company had a direct license to manufacture such tubes under the DeForest patents, 4) that the Fleming–DeForest [litigation] would not stand another Court action and that they were prepared to fight any action brought against them under the Fleming patents, and 5) that his company was flooded with inquires from all over the countries [sic]."

On June 6, 1921, William Pelzer of Radio Audion responded to RCA's letter of April 19 with a letter of his own informing RCA that he had received an opinion and report from his attorney advising him that 1) "…our 'Universal Radio Audion RAC-3' does not constitute an infringement of the Fleming patent No. 803,684, and that the Fleming Patent, in his opinion, is invalid," and 2) "We are informed that the rights your client may have under these DeForest Patents are only such non-exclusive rights as were obtained from the Western Electric Company, whereas our rights were derived directly from the owner of said patents and run for the life of said patents."

Radio Audion also prepared an ad for the RAC-3 in June 1921 that appeared in a number of consecutive issues of *QST* beginning in July 1921 (see Fig. 6). The ad stated the RAC-3 could be used as an audio amplifier, a radio frequency amplifier and an audion oscillator. It also contained a statement that the tube was not to be

Fig. 6. The RAC-3 designation for the Radio Audion tube first appeared in this ad placed in the in the June 1921 issue of *QST*, an ad that appeared in every issue of *QST* thereafter through August 1922.

used as a detector and warned that sale or use of the tube as a detector could subject the seller or user to prosecution for infringement of unspecified patents. With a bit of hubris, the ad contained the following words that could not have been lost on RCA executives: "After November 7th, 1922 the RAC-3 Audion will be available as a Detector and no longer limited for use in tandem with another device as a detector." November 7, 1922, of course, was the date that the Fleming patent was to expire.

RCA Resorts to Litigation

After receiving the June 6, 1921 letter from Pelzer, RCA and AT&T began the process of preparing the bill of complaint against Radio Audion. This process was memorialized in scores of unpublished letters between and among RCA, AT&T, Radio Audion and their respective attorneys during the period June 17 to September 29, 1921, the date suit was filed against Radio Audion. The contents of these letters are of some historical interest because they provide insights into the weakness of RCA's legal position in bringing suits based on infringement of the Fleming patent, and AT&T's reluctance to participate in suits on behalf of RCA based on infringement of the DeForest patents. A suit by RCA against Radio Audion based on the Fleming patent was a relatively simple matter because RCA as successor to the Marconi Company was the owner of the patent, and therefore did not require involvement of AT&T. On the other hand, a suit by RCA under the DeForest patents would have been more complicated because RCA as a licensee would require participation by the patent owner. Since RCA's license came from AT&T through an assignment to GE, it would require participation of both GE and AT&T. AT&T initially agreed to be a party to the suit as a defendant in order to satisfy a requirement of the law that the patent owner must be a participant in a patent infringement suit, whether it be as a defendant or plaintiff.[31]

AT&T and RCA decided to name DeForest as a defendant as well, alleging that DeForest had violated the terms of its 1917 agreement with AT&T by making an agreement with Radio Audion which, in effect, aided and abetted Radio Audion's infringement of the DeForest patents transferred to AT&T. As a result, the decision was made to file suit in Delaware where both the DeForest and Radio Audion Companies as Delaware corporations could be properly served. The circuit court of New York, perceived by all to be friendly to RCA, was not available to RCA because Radio Audion was neither a New York Corporation nor did it have a place of business in New York. Thus, the ploy to create a new company incorporated in Delaware to avoid suit in the New York court succeeded for Radio Audion, as planned.

While RCA had sent Radio Audion a cease-and-desist letter earlier, AT&T had not, and so George Folk, General Patent Attorney for AT&T, sent his version of a cease-and-desist letter on Sept. 15, 1921, closing with the following admonition: "Under the circumstances,

therefore, we feel that, to protect this Company's own rights, as well as in justice to its licensees, suit should be brought against you by this Company because of such infringement. We propose to take such action within a few days, unless you promptly give us assurances that your infringing acts will immediately cease." From this closing paragraph it would appear that AT&T had decided to join RCA in the suit as a plaintiff.

Radio Audion responded with a letter of its own dated Sept. 21, 1921 stating it was their understanding that the DeForest Company was the owner of the title of the patents in question and therefore had the right to license Radio Audion, implying AT&T's quarrel was with DeForest and not with Radio Audion. AT&T responded by informing Radio Audion that they did not accept Radio Audion's understanding that DeForest had retained ownership of the title to his patents, and stated further that DeForest would be a defendant in the suit.

Immediately following this exchange of letters regarding ownership of the DeForest patents, AT&T decided not to participate in the suit and suggested to RCA that it should file suit against Radio Audion on the Fleming patent without involving AT&T, DeForest, or the DeForest patents.[32] This was a stunning turn of events, given AT&T's extensive involvement in planning for the litigation over the previous six months—not to mention the cease-and-desist letter that AT&T sent to Radio Audion threatening suit just days before. In the end, AT&T declined to participate as a plaintiff because AT&T executives believed it would be bad publicity for three large companies to sue one small company. The ultimate motivation for AT&T demurring was that it did not want to jeopardize the monopoly it was busy creating in the telephone business by bad publicity from a lawsuit that was of little concern to its core interests.[33]

Ira Adams, RCA's in-house attorney, made it clear in later correspondence that AT&T had refused to participate in any litigation with Radio Audion until RCA had first sued Radio Audion under the Fleming patents. Adams wrote a letter to Sheffield & Betts dated January 28, 1922 stating: "As I told you personally the other day, suit should have been brought on the DeForest patents at the same time it was brought on the Fleming patent. I understand that the Telephone Company refused to cooperate in this respect until we had brought suit on the Fleming patent."[34]

RCA filed suit against Radio Audion in Wilmington, Delaware on September 30, 1921 with allegations limited to infringement of the Fleming patent. AT&T did not participate in the suit, and DeForest was not named as a defendant. RCA asked the court for an injunction to prevent Radio Audion from manufacturing or selling audions until trial. The case was heard before Judge Morris, who agreed to a preliminary hearing on the motion for injunction on October 27. Radio Audion was represented by Darby & Darby, the same law firm that had represented

DeForest in its numerous lawsuits. Briefs were prepared and exchanged during the month of October, and final arguments on the motion were made at a hearing attended by both parties on November 17, 1921.

Judge Morris handed down a memorandum opinion on the motion for a preliminary injunction on January 20, 1922 in which an injunction was granted as to claim 1 of the patent, which enjoined Radio Audion's device when used as a detector.[35] However, the judge refused to grant an injunction for the audion when used as an amplifier or as a generator of high frequency oscillations. This result was entirely unsatisfactory to RCA since Radio Audion could continue to manufacture and sell tubes for use as an amplifier and oscillator until trial, a trial that would most likely not conclude before Nov. 7, 1922 at the earliest—the expiration date of the Fleming patent. The result unfavorable to RCA was not entirely unexpected, inasmuch as it was the same unfavorable result that RCA obtained in the California Circuit Court of San

IN THE DISTRICT COURT OF THE UNITED STATES

For the District of Delaware.

RADIO CORPORATION OF AMERICA, Plaintiff,
v.
RADIO AUDION COMPANY, Defendant.

No. 439 In Equity. On Motion for Preliminary Injunction.

Radio Corporation of America charges Radio Audion Company with infringement of claims 1 and 37 of Letters Patent No. 803,684 to John Ambrose Fleming, dated November 7, 1905, by making, using and selling a radio or wireless telegraph and telephone device known as an "audion." A motion for preliminary injunction has been heard upon bill, affidavits and documentary evidence. I have examined the record and have studied the briefs of the respective parties with care. Defendant's device may be used as a detector, an amplifier and as a generator of high frequency electrical oscillations. As the record now stands I think claim 1 of the patent is valid and that defendant's device, when it is used as a detector, falls within that claim. This makes it unnecessary to determine whether claim 37 is invalid for want of a supplemental oath, but assuming that claim also to be valid I am not satisfied by the present record, consisting largely of *ex parte* affidavits, that the defendant's device when used as an amplifier or as a generator of high frequency electrical oscillations falls within the scope of either of those claims, and consequently the defendant should not now be enjoined from making or selling its devices for the latter uses. I think a more elaborate expression of views at this time would serve no useful purpose.

A decree directing the issuance of a preliminary injunction enjoining and restraining the defendant from making or selling its device for use as a detector may be submitted.

(sgd) HUGH M. MORRIS, J.

January 20, 1922.

ANNOUNCEMENT.

The Radio Audion Company desires to inform the Radio Trade that its position regarding the Fleming two-element rectifier patent (which expires on November 7th, 1922) was sustained in a recent decision by the Hon. Hugh M. Morris, United States District Judge for the District of Delaware, which decision is reproduced on the opposite page.

This company when it began business offered its RAC-3 Audion for use as an Audio and Radio Frequency Amplifier and Oscillation Generator, and refrained from offering it for sale or use as a Detector. At the argument of a motion for preliminary injunction on November 17th, 1921, in a suit brought by the Radio Corporation of America in October, 1921, to restrain the Radio Audion Company from making and selling the RAC-3 Audion as a detector, amplifier or oscillator, this company was not concerned with the question of infringement of the Fleming patent by a three-element audion, when used *solely* as a detector, but the doubtful validity of that patent was called to the attention of the Court. Infringement of that patent, however, by a three-element audion, when used as an amplifier or as an oscillation generator was contested by us, notwithstanding the decisions previously obtained in favor of the patent on those two points, with the result that the Court refused to grant a preliminary injunction prohibiting our manufacture and sale of the RAC-3 Audion for use as an amplifier or as an oscillation generator.

In view of this decision, the Radio Audion Company will continue its policy of manufacturing and selling audions for use only as amplifiers and oscillation generators for amateur or experimental purposes, i. e., where communication by radio is conducted without pay. After November 7th, 1922, the RAC-3 Audion will be available for use as a detector.

RADIO AUDION COMPANY.

SAME CIRCULAR REPRINTED MARCH 15th, 1922.

Fig. 7. Radio Audion issued this circular dated on Feb 1, 1922 to inform the radio trade that Judge Morris, District Court of Delaware, refused to grant the preliminary injunction RCA was seeking to prohibit the manufacture and sale of the RAC-3 Audion.

Francisco when it sued Elmer Cunningham and his AudioTron Company for infringement under the Fleming patent in March of 1920.[36]

Radio Audion wasted no time in assembling a circular dated January 20, 1922, which it issued on February 1, 1922 to inform the radio trade of the court's findings favorable to Radio Audion. The circular reproduced here as Fig. 7 pointed out that "when it began business, it offered its RAC-3 Audion for use as an Audio and Radio Frequency Amplifier and Oscillation Generator, and refrained from offering it for sale or use as a detector." It finished by stating "after November 7th, 1922, the RAC-3 Audion will be available for use as a detector." The first statement was somewhat self-serving because it was well known that RCA could not monitor the usage of the tube after it was sold to amateurs and experimenters. The last statement referring to the date that the Fleming patent expired must have nettled RCA executives, because they referred to it more than once in internal correspondence.

Judge Morris required Radio Audion to notify potential buyers that its tubes must not be used as a detector by affixing a warning label on each tube, inserting a warning notice printed on a sheet of paper inside the tube

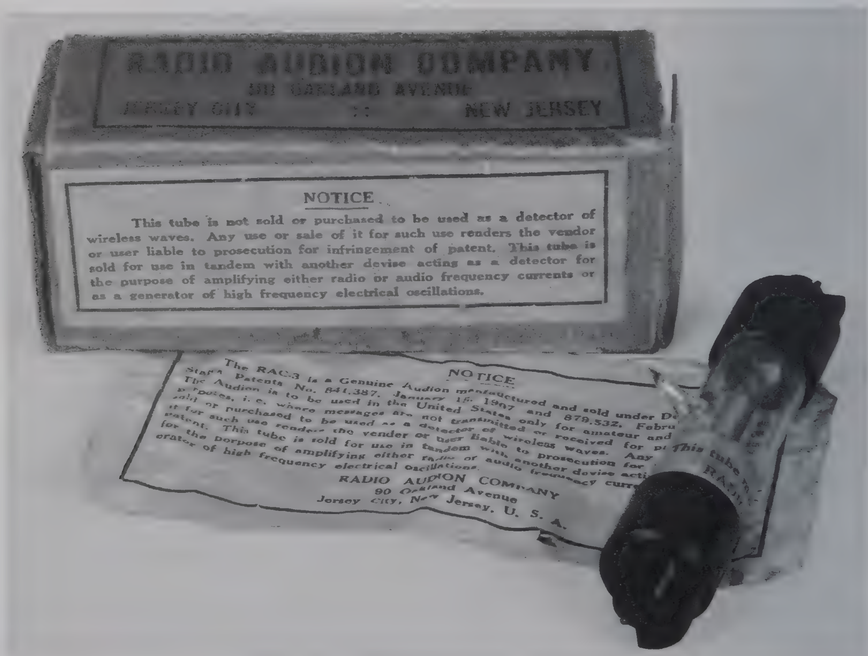


Fig. 8. Judge Morris required Radio Audion to warn customers that the RAC-3 could not be legally used as a radio detector by affixing a warning notice on the outside of each tube carton, inserting a warning notice inside the tube carton, and wrapping a warning label around each individual tube.

carton, and printing a warning notice on the outside of each tube carton. These three warning labels prepared by Radio Audion and approved by the court are shown in Fig. 8. All RAC-3 tubes and boxes sold after January 20, 1922, the effective date the injunction proscribing the use of the tube as a detector, carried these labels.

AT&T Files Suit Against Radio Audion: While RCA may have lost the first round in litigation with Radio Audion, AT&T had pledged that it would bring suit against Radio Audion in the event that RCA failed to obtain a preliminary injunction preventing Radio Audion from selling its tubes. True to its word, AT&T filed a bill of complaint against Radio Audion on February 11, 1922, just three weeks after Radio Audion received the favorable ruling from Judge Morris in the RCA suit. The bill of complaint included a motion requesting a preliminary injunction against Radio Audion to prevent it from selling any three-element audions that infringed on the DeForest patents. Radio Audion was given until February 27, 1922 to file affidavits in opposition to AT&T's request for an injunction. Judge Morris decided wholly in favor of AT&T on April 22, 1922, finding that the immunity agreement between DeForest and Radio Audion was in effect a license that DeForest had no power to grant.[37] Judge Morris also found that DeForest was a contributory infringer by entering into an immunity contract with Radio Audion, which aided and abetted Radio Audion in their infringement of AT&T's rights under the DeForest patent.

On April 28, 1922 Judge Morris issued a decree for a preliminary injunction to stop Radio Audion from manufacturing or marketing any three-element vacuum tube. Not surprisingly, Radio Audion appealed the preliminary injunction to the Delaware Circuit Court of Appeals shortly after the decree was issued. As a result, the preliminary injunction was put in abeyance pending a ruling from the appeals court. A ruling from the appellate court was not expected until the end of 1922 at the earliest.

RCA Resorts to Self-Help

Despite all the warning letters and legal actions taken by both RCA and AT&T in the previous two years, Myers and the Radio Audion Co. were still able to legally sell their audion tube as an amplifier and oscillator. RCA executive David Sarnoff must have been exceedingly frustrated by the adverse decisions of Judge Morris because he decided to take action by sending a two-page letter dated July 1, 1922 to manufacturers, distributors, jobber and dealers of vacuum tubes informing them of their potential liability in selling tubes that infringed upon either the Fleming patent or the two DeForest patents. The letter was carefully crafted such that each paragraph appeared to be accurate, but in fact, the letter taken as a whole was highly inaccurate and misleading. This letter exemplifying how far Sarnoff could go in dealing with his enemies is of some historic value, and

is reproduced here as Appendix A. This particular copy of the letter was annotated by RCA staff members who were dealing with the problems it created.

Sarnoff began the letter by stating that vacuum tubes of a very inferior quality that infringed upon the patent rights owned by the Radio Corporation of America under Fleming and DeForest patents had appeared in various portions of the country. It went on to say that the Radio Corporation had been vigorously prosecuting suits to protect its rights under these patents and intended to continue doing so. The next paragraph stated that patent suits had been instituted and injunctions had been obtained against a number of concerns. A list of twenty-four concerns followed, including the Radio Audion Co. whose name appeared prominently at the top of the second page. Finally, the letter requested that manufacturers, distributers jobbers and dealers cease the manufacture, sale or distribution of tubes that infringed the Fleming or DeForest patents, lest they be become individually liable for damages and profits.

While the letter did not specifically state that the Radio Audion tubes were inferior, there were only two companies on the list that were manufacturing tubes in this time frame—Radio Audion and Moorhead. Virtually all of the other entries on the list were either distributors or retail outlets. The reader of this letter would have concluded that Sarnoff was characterizing either or both the Moorhead and Radio Audion tubes as being "of a very inferior quality." However, it is clear from articles in radio trade magazines that the Radio Audion tube was as good as or perhaps better than the RCA Radiotrons. For example, the author of an article in the September 1922 issue of the *QST* radio magazine wrote: "The Moorhead A.P. tube is most in favor for this season, followed by the R.A.C. 3 audion, then the Radiotrons."[38] The following year, a *Radio News* editor also praised the RAC-3 tube, giving it ratings equal to or better than RCA tubes when used as an audio and radio frequency amplifier, detector, and oscillator (see Fig. 9).[39]

Furthermore, while the letter did not specifically state that manufacturers, distributers, jobbers and dealers would be subject to litigation for selling Radio Audion tubes, it did state that injunctions had been obtained against Radio Audion, thereby implying that anyone who sold Radio Audion tubes would be liable for prosecution. What the letter did not state was that the injunction in the RCA suit applied only to Radio Audion tubes when sold as a detector—which Radio Audion had specifically avoided—and that the injunction in the AT&T suit was in abeyance pending appeal. Consequently, distributors and dealers were free to sell Radio Audion tubes as amplifiers and oscillators without fear of being sued by either RCA or AT&T.

General Manager Pelzer immediately took exception to this letter and filed a motion with Judge Morris requesting a restraining order to prevent RCA from further distribution

of the letter. He also asked the court to compel RCA to write a follow-up letter to all recipients of the first letter clarifying that there was no injunction against the RAC-3 Audion under the Fleming patent when used as an amplifier or oscillator, and that the preliminary injunction issued under the DeForest patents in the AT&T litigation was in abeyance pending appeal. For good measure, Radio Audion also filed a suit in Federal Court in Wilmington, Delaware against RCA alleging unfair trading practices and claiming $1,000,000 in damages based on the facts upon which the motion for contempt was made. Radio Audion was joined in this suit by the Radio Supply & Services Corp., a major distributor for Radio Audion. (It would come out later than none other than Elman Myers was the president of this company, which was created specifically to market the RAC-3 tube.)

With regard to the circular mailed by RCA, Judge Morris was of the opinion it was unfair and had injured Radio Audion because it failed to state that the DeForest injunction had been suspended and that the Fleming injunction related only to the detector.[40] At a hearing for the motion on contempt held on July 26, 1922, Judge Morris ruled in favor of Radio Audion, and enjoined the Radio Corporation from sending out any further circulars. He also ordered RCA to supply a mailing list to the Clerk of the Court containing names of all parties to whom the RCA circular was sent, and directed the Clerk to send out a letter to all recipients with a copy of the injunctions issued by Judge Morris in both suits.

RCA provided a list of 265 recipients

Type	"A" Filament Volts	Filament Current	Filament Watts Consumed	"B" Plate Voltage		"C" Negative Grid Voltage For Amp.	Detector	Radio Frequency Amplifier	Audio Frequency Amplifier	Power Amplifier	Oscillator
				Det.	Amp.						
UV 199	3.0	0.06	0.18	45	60 to 90	1 to 4.5	Good	Good	Good	Fair	.....
UV 200 C 300	5.0	1.00	5.0	22½	....	....	Good	....	....	....	.....
UV 201—A C 301—A	5.0	0.25	1.0	45	60 to 100	3 to 6	Good	Good	Good	Good	Good
UV 202 C 302	8.0	2.35	18.8	40 to 60	100 to 500	3 to 9	Fair	....	Good	Good	Good
WE "N" tube	1.1	0.25	0.27	22½	45	1 to 2	Good	Good	Fair	....	Good
WD—11 WD—12	1.5	0.25	0.37	22½	45 to 60	1 to 3	Good	Good	Fair	....	Good
VT 1	2.5	0.9	0.36	22½	45 to 96	1 to 3	Good	....	Good	Fair	Good
VT 2	7.0	1.35	9.45	45	45 to 350	1 to 40	Good	....	Good	Good	Good
216—A	6.0	1.35	8.1	45	45 to 150	1 to 12	Good	....	Good	Good	Good
RAC—3	4.0	0.8	3.2	22½	40 to 90	1 to 10	Good	Good	Good	......	Good
French tube	4.0	0.8	3.2	45	40 to 300	1 to 25	Good	Good	Good	Fair	Good

Fig. 9. In an article appearing in *Radio News,* the RAC-3 was characterized as one of the well-known makes—along with those manufactured by RCA, Westinghouse and Western Electric—and was rated as good as, or better, than most of these tubes. (*Radio News*, Sept. 1923, p. 272)

to the courts and the information stipulated by the judge was mailed out by the clerk of the court sometime in late August or early September. Shortly after the clerk sent the letter, Radio Audion discovered that RCA had sent not just one copy if its circular to each recipient, but twenty copies—obviously with the idea that each jobber, distributor or dealer would pass the circular on to its respective customers. Radio Audion believed that RCA's failure to disclose the fact that RCA actually sent out 20 times 256, or 5120 circulars—not just 256—was tantamount to willfully disobeying the Court's order, and so in early October of 1922, Pelzer filed a motion with supporting affidavits asking Judge Morris to find RCA in contempt of court and assess damages accordingly.

On Nov. 4, 1922, Judge Morris found RCA in contempt and set Nov. 15 as the date for a hearing to determine damages.[41] The key issue in determining whether RCA should be held in contempt was whether RCA was responsible for the dissemination of the additional 4864 circulars included in each of the 256 letters, which in turn depended on whether the recipients of the 256 letters were agents of RCA. In RCA's favor, there were no written agreements between RCA and its distributors and jobbers. However, the judge ruled that the existence of an "agency" does not require a written contract, but rather, could be inferred from the circumstances. The judge further ruled that RCA had the expectation that the additional 4864 circulars mailed to the distributors and jobbers would be passed on—as was done for previous circulars sent by RCA during the normal course of business—and therefore that an agency could be inferred.

At the November 15th hearing Radio Audion was unable to prove damages other than attorney fees and costs as a result of the additional 4864 circulars mailed out. Judge Morris assessed RCA the sum of $5,750 to cover Radio Audion attorney fees and costs, and an additional $91 for court costs. There is no record of any remedial action required on the part of RCA to notify those who received the additional circulars. By any objective standard, Radio Audion did not receive justice in this matter. RCA was not punished for sending the 256 misleading letters in the first place, nor were they punished in any meaningful way for hiding the fact that an additional 4864 circulars were sent, many of which were circulated to retail dealers.

Radio Audion Loses its Appeal

While RCA and Radio Audion were engaged in contempt proceedings during the summer and fall of 1922, the appellate court for the Third Circuit in Philadelphia was deliberating Radio Audion's appeal from Judge Morris's preliminary injunction issued in the AT&T suit. Final arguments in this matter were heard on November 2, 1922, and on December 15, 1922 the appellate court affirmed the preliminary injunction issued by Judge Morris (284 Fed. 1020).[42] Radio Audion was

thus enjoined from manufacturing or marketing its tubes pending a full trial.

There is no record of how Radio Audion responded to this turn of events. However, in December of 1922, a creditor of the Company, one Harry Upright, applied for a receivership in the equity branch of the U.S. District Court with a claim of $4,154.02.[43] James Murphy of Jersey City and Reginald Boyd of New York City were appointed joint receivers for Radio Audion. On January 2, 1923, the receivers posted a $1,000 bond and were granted a continuance of 45 days allowing them to carry on the business of the then-defunct Radio Audion Company. On January 29, the assets of the company were sold to one Jacob Ruppert for $5,000. It is probable that this Jacob Ruppert was actually Jacob Ruppert, Jr., a brother of the George E. Ruppert who had assisted with the incorporation the Radio Audion and also had an ownership position in the company. Jacob Ruppert, Jr. was a well-known brewer, financier and politician residing in New York City, and was owner of the New York Yankees at one time. What Jacob Ruppert's interest might have been in the assets of the defunct Radio Audion Co. is not known for certain, but one possible explanation is provided later.

The receivers reached an agreement with AT&T for a stipulated judgment in favor of AT&T using the same pleadings and affidavits as those used in the application for the preliminary injunction. A final decree was entered by Judge Morris against both Radio Audion and DeForest on January 19, 1923.[44] Radio Audion was permanently enjoined from manufacturing and selling tubes, and AT&T was granted the right to recover profits and damages from Radio Audion. DeForest was enjoined from issuing any further agreements granting immunity from suits associated with the two DeForest audion patents.

In order to determine the amount due AT&T for past infringements, Judge Morris appointed a master (an authority to ensure judicial orders are followed) to determine the number of tubes both manufactured and sold by Radio Audion. The master, working with representatives from both AT&T and Radio Audion, reported that Radio Audion began manufacturing tubes on Jan. 1, 1921 and ceased manufacturing operations on Jan. 9, 1923.[45] The master also reported that Radio Audion manufactured a total of 36,330 tubes during the two years its factory in Jersey City was in operation.

In the end, Judge Morris ruled that Radio Audion had made 36,330 infringing tubes, that damages to AT&T would be equal to a reasonable royalty that AT&T might have received under a license agreement, and that a reasonable royalty would be $0.80 per tube. The judge noted that the damages thus assessed amounting to $29,064 exceeded the profits that Radio Audion made from the tubes. The judge also awarded $50,000 in punitive damages.[46] The total amount of the judgment exceeded the $20,000 bond Radio Audion posted at the time of the appeal in April 1921 plus an additional $1,000 bond posted by the defendants in Jan.

1923, and so AT&T received considerably less than the amount awarded by the judge. It is interesting to note that this ruling was made on May 16, 1925, two years and five months after Radio Audion ceased operations in January of 1923. Why it took so long to make the final accounting and fix damages is not known, but Radio Audion was primarily responsible because of incomplete or missing records, and conflicting information and evidence regarding legitimate expenses and actual profits.

Did Radio Lamp Manufacture Tubes?

While the master said nothing about tubes being manufactured by Radio Lamp Corp., the predecessor company to Radio Audion Co., there were several vague references in RCA correspondence to tubes manufactured by Radio Lamp in a factory located in Verona, NJ. The fact that the master said nothing about tubes manufactured by Radio Lamp prior to the creation of Radio Audion does not necessarily mean that Radio Lamp did not manufacture infringing tubes. It could be that AT&T did not have sufficient information about tubes manufactured by the Radio Lamp Corp., or that AT&T did not want to complicate the litigation against Radio Audion by naming Radio Lamp Corporation, a defunct entity, as a defendant.

Clearly, Gerald Tyne writing in Saga of the Vacuum Tube was convinced that Radio Lamp did have a factory in Verona, and began manufacturing tubes as early as 1920: "Armed with this pledge of immunity [Nov. 25, 1919], which they claimed was a license, Radio Lamp manufactured tubes, including the RAC-3 in Verona, New Jersey. RCA did not take kindly to the introduction of the RAC-3, and on May 4, 1920, notified Myers and the Radio Audion Corporation that they were infringing the Fleming patent on the diode. Radio Lamp continued manufacture of tubes and reincorporated as the Radio Audion Company, Inc., on Sept. 4, 1920, in Delaware to escape New York jurisdiction, 'following the laws of self preservation,' and opened a factory at 90 Oakland Avenue Jersey City."[47]

While there were several letters in Tyne's files that made reference to a Radio Lamp factory in Verona, these letters do not provide convincing evidence that Radio Lamp actually had a factory situated there. As stated previously, it is believed that the facility referenced in these letters was actually the home of Elman Myers in Verona, who was at that time developing a tube in his laboratory that would later be designated the RAC-3. Perhaps most convincing evidence there was no factory in Verona comes from data supplied by the master in the AT&T vs. Radio Audion suit, which clearly indicates that the Radio Audion factory in Jersey City was a startup operation as of Jan. 1, 1921—not a functioning factory that was moved from Verona to Jersey City in October of 1920. These data, which provide an insight to the rate at which tubes were manufactured over the two-year period of production at the Radio Audion factory in Jersey

City, are summarized in the next few paragraphs.

The master's data published in the Federal Reporter show that Radio Audion began to manufacture tubes in Jersey City on January 1, 1921, four months after it rented factory space in Jersey City on October 1, 1920. The master reported in aggregate for three consecutive but unequal periods between Jan. 1, 1921 and Jan. 9, 1923. The first period of approximately 16 months corresponded to the time from which Radio Audion began manufacturing tubes to the time a security bond of $20,000 was given and Judge Morris suspended the preliminary injunction. The second period of approximately 7 months covered the time from when the injunction was suspended to Nov. 30, 1921, the time when the receivers took charge of the Company. The third period of 1⅓ months covered the time from when the receivers took charge of the company to Jan. 9, 1922, the time when the $1,000 bond expired, a bond which had allowed the receivers to operate the company on a temporary basis.

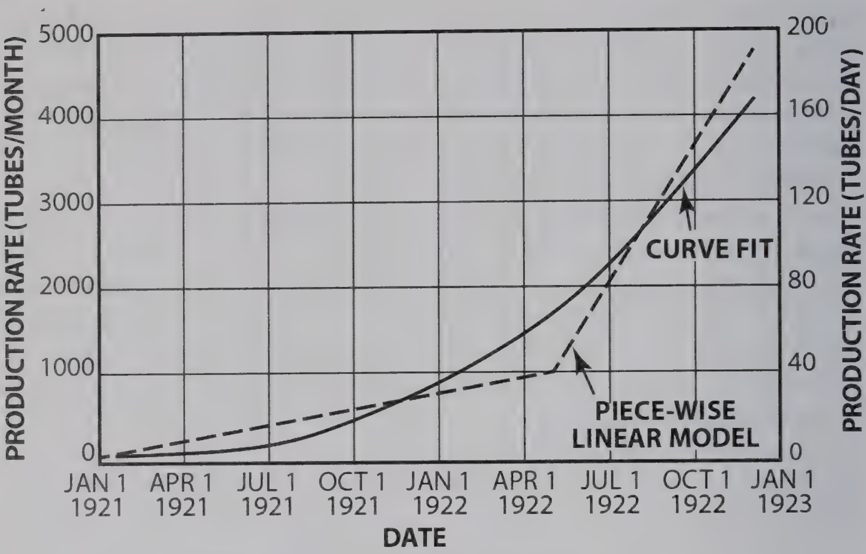
The number of tubes manufactured and the number sold for the three periods as reported by the court-appointed master are shown separately in the second and third columns of Table 1. The number of months in each of the three periods is shown in the fourth column, and the average number of tubes manufactured per month for each period (e.g., the total manufactured in each period divided by the number of months in the period) is shown in last column. The production rate increased substantially from an average of 540 tubes per month for the first period to 2980 tubes per month for the second period, which means that the actual production rate towards the end of the-first period must have been substantially higher than at the beginning of the first period.

While there are insufficient data to accurately characterize the actual production rate over time, an estimate can be made by assuming a monotonic increase in vacuum tube production during each of the first two periods (i.e., increasing or remaining constant, but never decreasing), and

Table 1. Number of Radio Audion RAC-3 tubes manufactured and sold in the three periods shown as determined by a court-appointed master. (*Federal Reporter*, 5 F2d 535)

Period	No. Mfg. Per Pd.	No. Sold Per Pd.	Mo.'s in Period	No. Mfg. Per Mo.*
1/1/21 – 5/02/22	8,650	8,570	16	540
5/3/22 – 11/30/22	20,868	19,194	7	2980
12/01/22 – 1/09/23	6,812	5,698	1.3	5240
Total	36,330	33,462	24.3	-

*Assumes a uniform distribution over the entire period



Fig, 10. The very low initial tube production rate in the six months after the opening of the Radio Audion factory in Jersey City on Jan. 1, 1921, followed by a rapid increase in production rate for the next 18 months, is indicative of a start up situation—not the move of an existing Radio Lamp factory from Verona to Jersey City.

no discontinuities in the production rates at any point in time. The simplest model satisfying these conditions is the piece-wise linear model represented by the dashed line in Fig. 10, in which the production rate is assumed to be zero at the beginning of the first period and to increase linearly during the first two periods.

Perhaps a more realistic estimate of the production rate can be made by fitting a curve to the existing data such that the slope of the production rate is continuous at the interface between periods—unlike the piece-wise linear model that has discontinuities in the slope of the production rate at the interfaces. A cubic equation can be used to fit the data from the first two periods with the boundary conditions such that the total number of tubes produced in each of the two periods are correctly represented. The resulting production rate is represented by the solid line labeled "curve fit" in the figure.

According to this model, the tube production rate reaches only about 192 tubes per month after six months of production—amounting to only about 7 tubes per day. The inescapable conclusion is that the production rate was very low at the beginning, and it did not increase substantively during the first six months. Such a result would indicate that tube was still undergoing development and/or the production process was being developed or improved during the first six months.

In the next six months, the production rate had increased by five-fold to 900 tubes per month (35 tubes per day), and after another twelve months the rate jumped five-fold again to 4750 tubes per month (180 tubes per day).

It is difficult to see how such a tube production rate could result from any reasonable circumstances other than a startup operation. This conclusion is supported by the fact that Radio Audion did not begin to advertise its tubes on a regular basis in national magazines until July 1921. The rate of tube production during the first half of 1921 was very low (on the order of 7 tubes per day)—certainly too low to justify national advertising. However the production rate had increased substantially by July 1921, which most likely prompted Radio Audion to begin advertising in national magazines in July of 1921. Indeed, Radio Audion advertised in every issue of *QST* from July 1921 to August 1922.[48] It should be noted from Table 1 that Radio Audion was able to sell virtually all of the tubes it manufactured during each of the periods reported, indicating that the company's sales were limited by its ability to manufacture tubes, not to sell them.

The above observations when taken together are clear evidence that Radio Audion did not manufacture tubes before Jan. 1, 1921, and that the Radio Audion factory was a start-up operation as of January 1, 1921—not a producing factory that had been moved from another location such as Verona. It is clear that the tube with the RAC-3 designation dates from 1921 when Radio Audion Company started production, not 1920 as many historians have stated.[49] Anecdotal evidence based on surviving artifacts also supports the conclusion that Radio Lamp did not manufacture tubes in Verona or anywhere else. There are no known tubes or tube boxes marked with the Radio Lamp name, no known advertisements by the Radio Lamp Corp., and no known address for a Radio Lamp Corp. factory in any historical documents.

Disposition of the RCA v. Radio Audion Suit

After AT&T successfully enjoined Radio Audion from manufacturing and marketing its tubes in November of 1922, RCA no longer had any reason for continuing the prosecution of its still-pending lawsuit against Radio Audion. RCA could no longer recover damages from Radio Audion because it was in the hands of receivers and under protection of the court. However, disposing of the suit was something of a problem for RCA. If a plaintiff requested the dismissal of a suit, the judge could dismiss the suit in favor of the defendant "on the merits"—which in this case would mean that RCA could be held liable for damages arising from the preliminary injunction it was granted prohibiting Radio Audion from selling its tube as a detector. Worse yet, the findings in this suit could be used in the still-pending $1M damage suit filed by Radio Audion and Radio Services Co.

The case had been removed from the

calendar earlier in 1922 because neither RCA nor Radio Audion had scheduled any activities on the Court's calendar after AT&T filed its suit against Radio Audion. RCA was waiting for the suit to be dismissed by the court for lack of timely prosecution—not an uncommon a practice to quietly dispose of a suit. In a surprise move, the attorneys for Radio Audion who had defended the AT&T v. Radio Audion suit in Wilmington, Delaware (not the attorney for the court-appointed receivers), requested permission at the beginning of June 1923 term of the District Court to file a motion to restore the case to the trial calendar. RCA opposed the motion, but nevertheless the Court allowed Radio Audion to file, and on July 9, 1923, the Court granted the motion to restore the case to the trial calendar for the December 1923 term. What followed for another year and a half was a cat-and-mouse game between attorneys for RCA and Radio Audion.

Just as the case was about to go to trial in December 1923, RCA learned that the attorneys representing the defendants were actually Darby & Darby, attorneys for both Radio Audion and DeForest. It turned out that the receivers, who were required to become defendants in the AT&T v. Radio Audion suit, had not been listed as defendants in RCA vs. Radio Audion suit—and, in fact, neither the receivers nor their attorney were even aware of that suit. RCA surmised quite correctly that DeForest—not Radio Audion or its receivers—was actually paying Darby & Darby to reinstate the case with the intent of retrying the Marconi v. DeForest suit of 1916 in which the DeForest audion was found to infringe on the Fleming valve patent.

RCA prepared a motion in early March of 1924 asking the court to dismiss the case with a stipulation that the dismissal would not constitute a decision on the merits. Darby & Darby opposed the motion on the pretext that they wanted to recover damages from RCA for causing the injunction to be granted prohibiting the RAC-3 to be sold as a detector, and then failing to prosecute the case. RCA had been required to post a $10,000 bond for just such an eventuality. However, Darby & Darby's hidden agenda was to retry the Fleming v. DeForest patent suit with the hope that Judge Morris would rule in favor of DeForest on the infringement of the Fleming patent when the tube was used as an amplifier or oscillator as well as a detector. A favorable ruling would have helped DeForest greatly because the DeForest Company still owed substantial damages to the residual Marconi Co. interests as a result of losing the Fleming patent infringement suit to Marconi in 1916.

After recognizing the hidden agenda, RCA then decided it would be best to withdraw the motion for dismissal and replace it with a motion to limit the question at trial to the RAC-3 when used as a detector—not as an amplifier or oscillator. RCA had an excellent chance of winning the litigation limited to the detector because the appellate court had ruled in Marconi's favor on the DeForest audion when

used as a detector, and all circuit courts had to take note of appellate court rulings, even in other districts. Darby & Darby strenuously opposed this motion when it was heard before Judge Morris on May 27, 1924. However, Judge Morris granted RCA's motion on June 19, 1924 because the preliminary injunction he issued previously had been limited to the RAC-3 when used as a detector. A trial was then scheduled, but it was to be limited to the use of the RAC-3 as detector, thereby avoiding a potentially dangerous situation for RCA.

RCA then decided the best course was to file another motion to dismiss the suit without attempting to avoid paying damages resulting from the preliminary injunction. Judge Morris granted this motion on March 21, 1925, finding RCA liable for $1,000 in damages. RCA promptly paid the Radio Audion receivers (not Darby & Darby or DeForest) the amount that Judge Morris had assessed, thus ending the suit RCA had filed on Sept. 29, 1921.

Disposition of the Radio Audion and Radio Supply & Services v. RCA Suit

Radio Audion and Radio Supply Services Co. had joined together to file a $1 million lawsuit against RCA in October of 1922 for damages resulting from "the alleged circulation by the Radio Corporation of false, malicious, slanderous and libelous statements concerning the plaintiff, such statements consisting [of] stating that the plaintiffs had been enjoined by the court from manufacturing and selling vacuum tubes, and that the plaintiff's product was a boot-leg or fly-by-night product." RCA moved to dismiss the bill in early 1923 on the basis that the court did not have jurisdiction in the case, and that the facts stated in the bill did not constitute a cause of action. The plaintiffs then amended their bill by striking Radio Audion Co. as a plaintiff and revising the pleadings. RCA renewed their motion to dismiss, but Judge Morris overruled the motion on the grounds that the questions raised were "of such a character that they should be determined only after final hearing upon the merits."

No further action was taken by the remaining plaintiff, Radio Supply & Services Co., as of December 1923—which was no surprise because Radio Supply & Services Co. had filed for bankruptcy circa April 10, 1923.[50] Further, its president, Elman Myers, had already left the U.S. to set up a new company in Canada. In a letter dated December 15, 1925, attorney James Cosgrove stated that if Radio Supply did take any action by August 28, 1926, the court would dismiss the case for lack of prosecution. RCA attorneys Sheffield & Betts suggested the best strategy at that point was to "let sleeping dogs lie." There is no record of any further actions in this suit, and so presumably it was dismissed on Aug. 28, 1926.

Thus ended the litigation that began with the RCA suit against Radio Audion on Sept. 29, 1921—five years and a month earlier. It is clear that Radio Audion got the best of RCA in this litigation, and had it not been for

AT&T, who came to RCA's aid by filing suit against Radio Audion, RCA may well have lost its near-monopoly on vacuum tubes.

E. B. Myers Co., Ltd. Incorporates in Canada

While RCA was extricating itself from lawsuits with Radio Audion Co. and Radio Supply & Services Co., Elman Myers packed his bags and moved to Montreal, Canada in early 1923 where he set about to open a new company for the purpose of manufacturing his vacuum tubes in a country that he considered to be safe from infringement litigation. According to government documents, the E. B. Myers Co., Ltd. was incorporated on August 11, 1923 with capital stock of 100,000 shares valued at $5 each.[51] The company was located at 240 Craig St. West in Montreal.

Elman Myers was Chief Engineer but did not have an equity position in the Company. Instead, he arranged to receive royalties on his tube patents, three of which had been filed in the U.S. circa Jan. 12, 1922. The three U.S. patent applications, clearly the most important ones, were apparently abandoned because, while they were filed in the U.S., there is no record of them being issued there. However, they were refiled in Canada at some point and issued as Canadian patents on Feb. 22, 1923.[52] The pertinent patents with Canadian Nos. 229182, 229183, and 229184 appear on most if not all of the tube cartons used on E. B. Myers tubes made in Canada. The signature page for the first of these three patents issued in Canada contains a line drawing of the RAC-3 originally prepared for the U.S. versions of the patents (see Fig. 11). This page has signatures of both E. B. Myers and his attorney Samuel E. Darby of New York, NY dated January 12, 1922, well before E. B. Myers Co. Ltd. was formed in mid-1923.

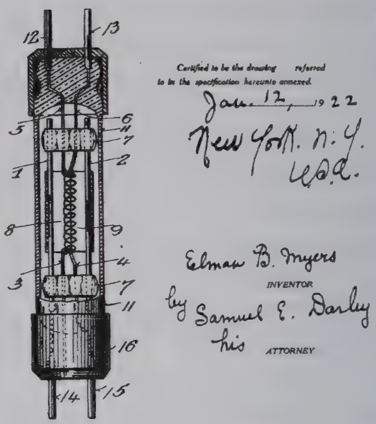


Fig. 11. The three Myers audion patents issued in Canada were originally filed in the U.S. as evidenced by excerpts from the signature page from one of the Canadian patents with signatures by E. B. Myers and his attorney Samuel E. Darby of New York, NY, which was dated January 12, 1922, long before E. B. Myers Ltd. was formed. (Myers Canadian Patent 229182A)

It is interesting to note that the Canadian patents were assigned to the Radio Audion Company, the legal owner of the patents. Exactly how the ownership of these patents was transferred to the E. B. Myers Co., which was not incorporated until August 11, 1923, is not known for certain. One logical explanation is provided by the fact that the assets of Radio Audion

had been purchased on Jan. 29, 1923 by Jacob Ruppert, believed to be the brother of George Ruppert, an original investor in both Radio Lamp Corp. and Radio Audion Co. It is plausible that the patents were part of the assets of Radio Audion purchased by Jacob Ruppert, and that Ruppert had ownership of the Canadian patents issued in February 1923 until the new E. B. Myers Company was formed in August 1923. Perhaps he then transferred patent ownership to the new company in exchange for cash or an equity position.

The E. B. Myers Company flourished under the direction of Samuel I. Levy, its first president. Ads soon began to appear in Canadian periodicals such as *Radio*, *Electrical News* and *The Radio Bug* in the second half of 1923. One of the Company's first ads shown in Fig. 12 appeared on the front cover of the September 1923 issue of *Radio*.[53] The two tubes appearing in this ad were the Myers Dry Battery tube requiring a filament current of only ¼ ampere and the Myers Universal tube with a filament designed for operation by either three dry cells or a storage battery.

Fig. 12. One of the first ads placed by E. B. Myers Co., Ltd. featured two different tubes, a dry battery tube for operation on two dry cells and the Universal tube for operation with three dry cells or a storage battery. (*Radio*, Sept. 1923, front cover)

An article appeared in the *Electrical News* magazine in December 1923 describing the making of tubes in the Canadian factory of Myers: "It is more like a laboratory than a factory and the first glance impression makes one aware that here is a scientific process rather than the mechanical production of a patterned article."[54] The article goes on to provide details of the various steps in the tube manufacturing process in a non-technical, if not poetic manner: "Hissing jets of flame play upon tubular glass which is turned by the operators so that the melting glass takes care of a dozen tube cases at a time, but the operator must know exactly when the glass has reached the right melting stage and change over the tubes to the unfinished ends." The article emphasized, "intricate machines and skilled workers are essential accessories to production."

The E. B. Myers Company began to place ads in U.S. magazines with national distribution in 1924, most notably *QST* and *Wireless Age* beginning in January, and *Popular Radio* and *Radio News* beginning in February. The ad

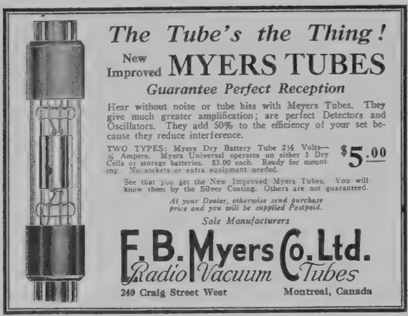


Fig. 13. Throughout 1924, the E. B. Myers Company placed ads such as this one in U.S. radio magazines with one or two catchy taglines to capture the reader's attention. (*Wireless Age*, March 1924, p. 87)

content changed from month to month, with similar ads eventually appearing in all magazines—although the same ads were rarely duplicated in magazines published in the same month. Each of these ads had one or two catchy taglines to capture the reader's attention such as the one shown in Fig. 13 with the tagline "The Tube's the Thing! – New Improved Myers Tubes Guarantee Perfect Reception."[55] The taglines used in these ads changed every month, many of which were amusing, if not quite accurate. For example: "Practically Unbreakable" followed by "You can't break 'em unless you deliberately try," or "10,000 Miles With One Myers" followed by "This performance indicates there is no limit to long-distance reception with Myers tubes," and "The Myers 100% Efficient" followed by "noise and tube hiss are completely banished, perfect reception follows."

The earlier ads offered only two tubes types for sale, a "Dry Battery" type and a "Universal" type for storage batteries. Some ads advertised the Universal type as operating on storage batteries while others advertised it operating with either three dry cells or storage batteries. All ads suggested that Myers tubes could be purchased through reliable dealers or postpaid through the mail by sending the purchase price, but of course the tubes could not be legally sold in the U.S., and so few if any reputable dealers in the U.S. would have handled their product. Most of the Company's sales in U.S. must have been transacted by mail order, a business that would have been very difficult for the authorities to monitor. Cylindrical tube mailers with the E. B. Myers Co. name stamped on the outside have been observed; the one shown in Fig. 14 entered at a post office in Detroit with U.S. postage due stamps totaling 5 cents. It would appear that a number of tubes were carried across the U.S. border for mailing in the U.S., perhaps to evade customs scrutiny given to international mail.

The early ads also stated: "See that

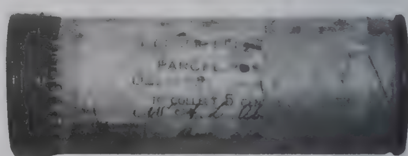


Fig. 14. This cylindrical tube mailer with an E. B. Myers Co. label and several U.S. postage due stamps totaling 5 cents entered the U. S. postal system in Detroit, MI, suggesting that E. B. Myers tubes made in Canada may have been carried across the U.S. border for mailing in the U.S to evade customs scrutiny given to international mail. (Courtesy of Jerry Vanicek)

you get the New Improved Myers Tubes. You will know them by the Silver Coating. Others are not guaranteed." The silver coating refers to a flashed getter coating applied to the inside surface of the glass tube to create a higher vacuum, which would have indeed improved tube performance, particularly as an amplifier. The coating was most likely magnesium, an element favored for use in getters at that time.[56] Up to that point, E. B. Myers had been selling tubes without a getter. The reference to "others" in the phrase "Others are not guaranteed" most likely referred to the phrase "Guarantee Perfect Reception" appearing elsewhere in the ad. In essence, the Myers Company began to guarantee "perfect reception," but only for its improved tubes with getters; earlier Myers tubes without getters were not to be covered by this open-ended guarantee.

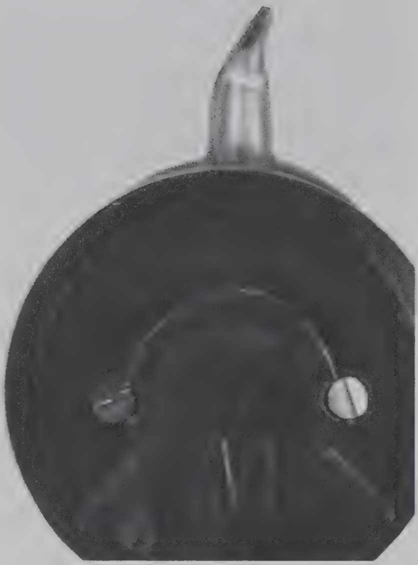


Fig. 16. Another positive marker for E. B. Myers tubes is the letter "M," which is molded onto one or both end caps.

Fig. 15. The presence of the silvered coating is a positive marker that confirms the tube was made by the E. B. Myers Company or its successor company in Cleveland (upper tube); however the absence of the coating is not a positive marker for RAC tubes because E. B. Myers also made tubes without a silvered coating (lower tube).

Positive Markers for E. B. Myers Tubes

The presence of the silvered coating is a positive marker that confirms the tube was made by the E. B. Myers Company (or its successor company in Cleveland) and not the predecessor company, Radio Audion. However, since E. B. Myers also made tubes without the silvered coating, the absence of the coating is not a positive marker for a tube made by Radio Audion (see Fig. 15). Another positive marker for E. B. Myers tubes is the letter "M," which is molded onto one or both end caps (see Fig. 16). However, since a few E. B. Myers tubes with silvered coatings have been observed without a letter

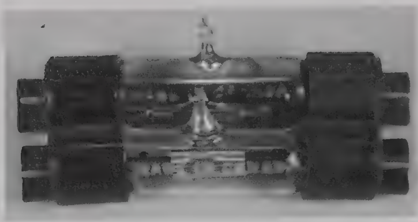


Fig. 17. The only imprinting observed on all E. B. Myers Company tubes examined is "Made in Canada;" no dates or serial numbers have been observed.

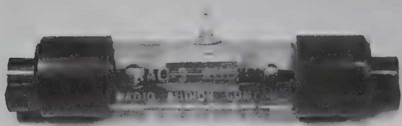


Fig. 18. One type of lettering observed on the glass wall of RAC tubes is "Myers Type" on the first line, "RAC-3 Audion" on the second, "Radio Audion Company" on the third, and although not apparent in this photo, "Jersey City, N. J." on the fourth; what appears to be serial numbers are imprinted on the opposite side, in this case "112810." (Courtesy of Stew Oliver)

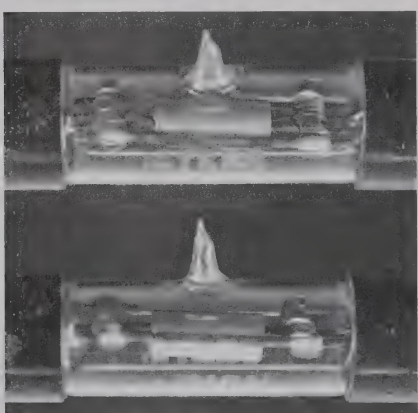


Fig. 19. A second type of lettering observed on the glass wall of RAC tubes is simply "Myers Audion" on two different lines with a date imprinted on the opposite side, in this case "5 25 22."

"M" on either end cap, it also does not follow that the absence of the "M" is a positive marker for a tube made by Radio Audion.

Words imprinted on the exterior of the glass tube, when present, are also reliable markers that distinguish tubes made in Canada from those made by Radio Audion. The only three words appearing on all E. B. Myers Company tubes examined are "Made in Canada" (see Fig. 17). On the other hand, two different sets of characters have been observed on the exterior glass of Radio Audion tubes. The first set consists of "Myers Type" on the first line, "RAC-3 Audion" on the second, "Radio Audion Company" on the third, and "Jersey City, N. J." on the last line (see Fig. 18). A series of numbers believed to be serial numbers appear on the opposite side of the glass (in this case 112810). The second set of characters consists of "Myers Audion" on one side (see Fig. 19), and three groups of numbers on the opposite side that clearly represent the month, day and year of manufacture (in this case 5 25 22). On one of these tubes the month is abbreviated rather than being designated by a number. Based on the dates and warning labels affixed to the tubes examined, it would appear that tubes with the second set of characters were manufactured later than tubes with the first set of characters. The sample size examined in this effort was not sufficiently large to conclude there are only two sets of characters appearing on RAC-3 tubes.

Some of the tubes examined had none of the three positive markers:

silvered glass, the letter "M" or words imprinted on the glass—either because the tubes were manufactured without the lettering, or more likely, because the lettering had worn off. Clearly, a positive marker that is present on every tube and that reliably distinguishes Radio Audion tubes from later Myer's tubes would be desirable. In the course of examining 40 or so tubes for this article, a potentially useful marker was discovered. The glass support beads for all tubes known to be made by Radio Audion were observed to be light and transparent, while the beads in all tubes known to be made by E. B. Myers Co. were observed to be decidedly darker and opaque (see Fig. 20). Whether exceptions to this observation will be found as more tubes are examined is not known.

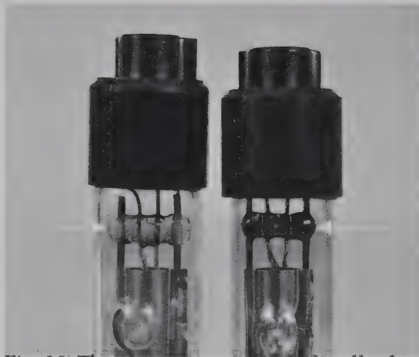


Fig. 20. The glass support beads for all tubes made by Radio Audion were observed to be light in color and transparent, while the beads in all tubes made by E. B. Myers were observed to be decidedly darker and opaque.

E. B. Myers Ads Evolve

Beginning in December of 1924, the Company's ads changed in three notable ways. Perhaps the most obvious change was the deletion of the company name E. B. Myers Co., Ltd. from all ads—the only reference to the Company being in the phrase "Myers Tubes" (see Fig. 21).[57] Less obvious was the use of new mailing addresses, which were slightly different in each magazine. The address of the E. B. Myers Co. that had been used in advertising since its inception was 240 Craig Street. However, this ubiquitous address was discarded in December 1924 in favor of 246 Craig Street in *QST*, 250 Craig Street in *Radio News* and 252 Craig Street in *Radio*. These address changes could have been

Fig. 21. Beginning in December of 1924, there were several changes in the Company's ads—most notably the deletion of the company name E. B. Myers, Co. Ltd. from all ads leaving "Myers Tubes" as the only reference to the Company, and the mention of a third tube type without specifying what type of tube. (*QST*, Dec. 1924, p. 66)

an attempt on the part of the Company to determine which magazine produced the most orders—something akin to the use of "Department" followed by a different letter for each magazine, a technique used in ads placed by many mail order companies. However, this explanation would not account for the fact that no address whatsoever appeared in ads placed in *Popular Radio* beginning with the July 1924 issue. The absence of any mailing address would seem to be problematic for a business that depended upon mail orders.

Perhaps the most perplexing change in the ads was the increase in the number of tube types offered from two to three. The new ads claimed: "three tube types for dry and storage batteries," but failed to state how the third tube type differed from the two previously advertised. The potential mail order customer had no way to determine the characteristics of the third tube type. Instructions sheet inserted into tube cartons sold later listed three tube types: "dry battery," "Universal," and "Hi-Mu" (see Fig. 22). Based on this insert, one can infer the new tube type referenced in the ads must have been the Hi-Mu amplifier. Note that Myers had already developed a high-mu tube at Radio Audion circa August 1922,[58] and advertised it for sale in the U.S. as early as January 1923 (see Fig. 23).[59]

OPERATING DATA		DRY BATTERY	UNIVERSAL	HI-MU
Filament Voltage		2.5	3.5 to 4	4.5 to 5
Plate Voltage (dect.)		22 to 45 V	22 to 45 V	22 to 45 V
Plate Voltage (amp.)		45 to 300 V	45 to 300 V	45 to 300 V
*Rheostat Resistance		30 Ohms	20 Ohms	20 Ohms
Grid Bias Voltage	B-45	2 to 3	2 to 3	2 to 3
	B-90	3 to 4	3 to 4	3 to 4
	B-135	5 to 6	5 to 6	5 to 6
Grid Condenser		.00025	.00025	.00025
Grid Leak		2 meg.	2 meg.	2 meg.

*Above values of resistance apply to separate rheostat on each tube.

Fig. 22. An instruction sheet inserted into tube cartons at some point in time listed three tube types: "dry battery," "Universal," and "Hi-Mu," which by process of elimination the user could deduce "Hi-Mu" as the new tube type.

Fig. 23. A Myers "high-mu" tube type had already been developed by Radio Audion circa August 1922 and advertised for sale in the U.S. as early as January 1923. (*Popular Radio*, Jan. 1923, p. 28)

The E. B. Myers Company also advertised in countries other than Canada and the U.S. The Company claimed it had developed markets in "all countries of the world," and that regular shipments were being made to "England, Australia, New Zealand, South America, Italy, Spain and other countries."[60] The Company also claimed that it sold more tubes in England than anywhere else. According to an article in *Electrical News*,[61] the firm of Cunningham and Morrison

Fig. 24. The firm of Cunningham and Morrison of London had been engaged as the representative of E. B. Myers Co., Ltd. in England in late 1923, and their ads such as this often appeared in British magazines during 1924. (*Experimental Wireless & The Wireless Engineer*, Sept. 1924, p. 12)

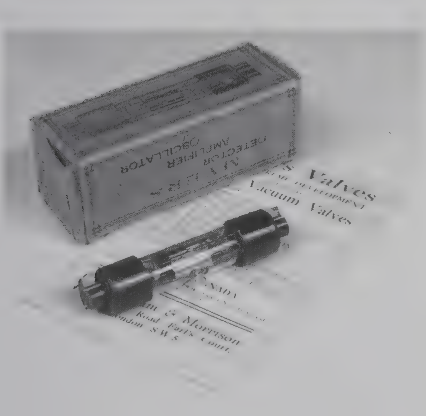


Fig. 25. The importance of Cunningham and Morrison to Myers is suggested by the fact that tubes sold by this company contained instructions in the tube boxes with the name Cunningham and Morrison printed at the bottom. (Museum of History of Science, U. of Oxford)

of London had been engaged as the representative of E. B. Myers Co., Ltd. in England in late 1923, and their ads such as the one shown in Fig. 24 appeared often in British magazines during 1924.[62] According to these ads, Cunningham and Morrison had agents located in a number of strategic points who sold Myers tubes including Manchester, Newcastle, Liverpool, Glasgow, Yorkshire and Southern Counties. The importance of Cunningham and Morrison to Myers is suggested by the fact that tubes sold by this company contained instructions in the tube boxes with the name Cunningham and Morrison printed at the bottom (see Fig. 25).

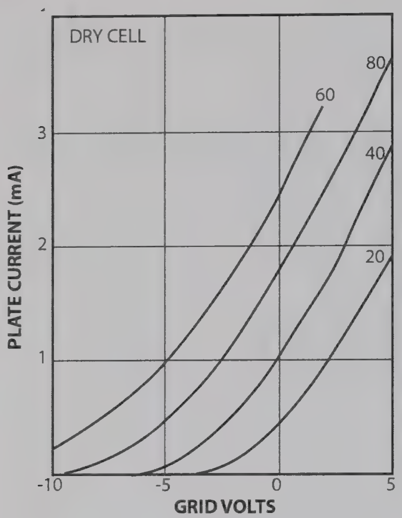


Fig. 26. In the Feb. 8, 1924 issue of *The Wireless World and Radio Review*, the editors published the results of independent tests performed on the E. B. Myers "Dry Cell" tube, concluding the tube was quite linear and would make an excellent amplifier.

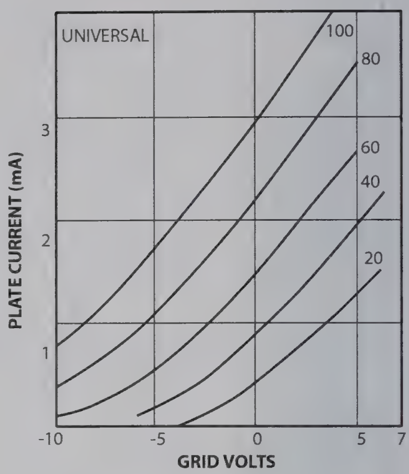


Fig. 27. In the Feb. 8, 1924 issue of *The Wireless World and Radio Review*, the editors published the results of independent tests performed on the E. B. Myers "Universal" tube, concluding the tube was quite linear and would make an excellent amplifier.

In early 1924, Cunningham and Morrison submitted Myers' Universal and Dry Battery tubes to *The Wireless World and Radio Review* for test and evaluation, the results of which were published in its Feb. 8, 1924 issue.[63] Based on the I-V characteristics for the two tubes shown in Figs. 26 and 27, the author concluded the two tubes were quite linear and would make excellent amplifiers. However, the author also found that the Dry Cell tube gave no emission at the advertised filament current of 0.25 amperes, and that 0.45 amperes was actually required to make it function properly.

The author also took special note of "the extremely rugged nature of construction" of both tube types "to ensure freedom from microphonic noises, a point of extreme importance when dealing with multi-stage amplifiers." This point was emphasized in an article by the well-known researcher and author Philip R. Coursey who, when experimenting with radio reception on trains, found that "the vibration of the train rendered the use of the receiver containing ordinary receiving tubes practically impossible, even though it was mounted on a soft cushion, etc."[64] He went on to state, "The rigid nature of the Myers valves in the second receiver, however, permitted its use without these troublesome microphonic noises."

E. B. Myers Co., Ltd. Moves to Cleveland

Despite the fact the E. B. Myers Co. appeared to be doing well in Canada, the Directors made a decision to move the Company back to the U.S. after the last of the DeForest tube patents expired on Feb. 18, 1925. The stated rationale was to better service the huge market potential in the U.S. It is likely that sales of the double-ended tubular audion were declining at this time as the mass market for broadcast radio receivers moved in the direction of improved tubes with lower filament currents and standard four-prong bases. Consequently, there was a need to design and manufacture new tubes types, which would have required additional capital.

The first public notice presaging this move appeared in the Jan. 27, 1925 edition of *The New York Times* announcing the incorporation of the Myers Radio Company in Delaware with a capitalization of $15,000,000 by the Corporation Trust Co. of America.[65] A few days later it was announced that The Myers Radio Co. had been incorporated for the purpose of taking over the E. B. Myers Co., Ltd. of Montreal[66]—and indeed, E. B. Myers Co., Ltd. was acquired by the new Myers Radio Corp. on Feb. 2, 1925, just one week after it was incorporated.[67]

At the end of February 1925, an advertisement appeared in the *Magazine of Wall Street* offering the unsold portion of 50,000 shares in the Myers Radio Corporation to the public at $5 per share.[68] The total number of shares authorized and outstanding was listed as 150,000. At the bottom of the advertisement was a statement that "Application will be made by the Corporation to list the stock on the New York Curb."[69] This advertisement is of some historical interest because it contains information about this U.S. Company that has not previously been chronicled. The information in this advertisement was quoted from a letter issued by the president of the Myers Radio Corporation, and while a copy of this letter could not be found, excerpts from this letter were reproduced in various New York publications including the *Magasine of Wall Street* advertisement.[70]

According to the information published in various New York journals, the factory of the new company was scheduled to open in New York City in March 1925. The production capacity of the new plant was to be 5,000 tubes per day, a ten-fold increase over the stated capacity of 500 tubes per day for the Canadian plant at the time. At the then-cost of manufacturing, the net profits after all deductions were projected to be $75,000 per month, assuming the plant was operating at its capacity of 5,000 tubes per day. Estimates of Company earnings for the first year were $5.00 per share on its authorized capital stock of 150,000 shares, or about $950,000.

It was stated that "Three types of tubes are at the present time being manufactured—the Myers Hi-Mu, an amplifier tube; the Myers 'Universal,' a detector tube, and the Myers Dry Battery, which operates on two

dry batteries and functions both as a detector and amplifier." It was further stated "we have under test, a tube with a four-prong base, which will be put on the market after February 1925."

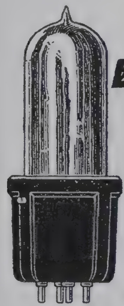
New York Commercial, quoting from the president's letter, reported: "...the guiding spirit in the company is E. B. Myers, chief engineer of the company who has a world wide reputation as a radio engineer." However, Elman Myers testified in the FTC hearings that after he left the E. B. Myers Company of Canada, he took a position as research and development engineer with the Music Master Company in Philadelphia.[71] Myers testified that the E. B. Myers Company had the right to the continued use the Myers name and chose to use it in the new operation in which Elman Myers did not participate.

Ads from the E. B. Myers Co. of Canada stopped altogether in U.S. magazines by May of 1925, and they stopped in some, if not all, Canadian magazines by August—which was no surprise because the plant in New York was supposed to open in March of 1925. However, the new plant did not open in New York or anywhere else in March, and virtually nothing was heard from the Company in the press until November. On Nov. 1, 1925, a short article appeared in the *Cleveland Plain Dealer* announcing that the Myers Radio Corporation was moving its factory from Montreal to Cleveland and would soon begin manufacturing there.[72] Factory space had been leased at 1890 E. 40th Street, and installation of tube-making equipment had begun. It was expected that the first Cleveland-made Myers tubes would be on the market within three weeks. Similar articles appeared in a number of newspapers and radio magazines across the country during the first two weeks of November.[73]

No reason was given for the delay in opening the plant or selecting Cleveland as the location to build the plant in lieu of New York City as originally planned. The opening of the plant might have been delayed until the new improved single-ended bases were designed and tested. The announcement that investors from the Cleveland area were involved in the new Company provides the only clue as to why the location of the plant was moved to Cleveland. How long the Canadian plant continued to produce tubes during the delay in the planned opening of the new plant from March to November is unknown. The reason for the hiatus in advertising or other public announcements during most of 1925 is also unknown.

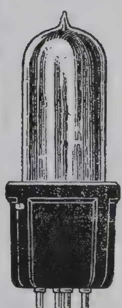
One of the first display ads for Myers tubes made in Cleveland was placed in the *Cleveland Plain Dealer* on Jan. 12, 1926 (see Fig. 28). This ad is most interesting because the company name in the ad was Myers Radio Tube Corporation (having the additional word "Tube" in the Corporate name). It would appear that the Company changed its name between the time it was incorporated as the Myers Radio Corporation and the time of this ad. The ad stated that Myers tubes were available in the following types: Myers 201A, Myers 201X, Myers 199, Myers 199X, and "Myers famous Double End

MYERS TUBES



Economy

Myers Tubes save battery current. They bring in signals without being forced. They are marvelously responsive, yet always under perfect control. Note the fine contour, the exclusive base design, the sturdy, practical construction. And the inside is even better than the outside.



The Only Tube

that is built like a bridge and can consequently be mounted in *any position* without injury to the filament or interference with operating efficiency.

The World On Your Dial

MYERS RADIO TUBES

Made in Cleveland

NOW READY Internationally famous Myers Radio Tubes are now ready for delivery from the new Cleveland plant, located at the heart of the Radio Tube Industry and equipped with the most modern apparatus for technical research and commercial manufacture.

A PIONEER TUBE Myers Radio Tubes are the product of pioneer Tube designers and have long been preferred for their outstanding merits of performance. They embody many exclusive features that are fully protected by patents pending and issued in the United States and foreign countries.

Technical Advantages The internal geometry of Myers Tubes gives them the highest mutual conductance and the maximum factor of amplification; consequently Myers Tubes are superior for universal use and operate equally well in transformer, impedance or resistance coupled circuits.

Practical Advantages

The double end supports for the electrodes make Myers Tubes practically unbreakable in normal use, and eliminate all microphonic effects. Myers Tubes have no dead spaces, no clumsy dimensions, no needless materials. They are small, compact, good to look at, and improve both the appearance and the operation of any set.

Marvelous Clarity

As a direct result of the numerous advantages in construction, Myers Tubes are unapproached for the remarkable performance in clarity and distance of reception, entirely free from noises and distortion. Precision manufacture makes all Myers Tubes uniform in characteristics. Matching Myers Tubes is unnecessary, and the addition of a new Tube has no effect on the balance of the circuit.

TYPES Myers Tubes are available in the following Types: Myers 201A, Myers 201X, Myers 199, Myers 199X, Myers famous Double End Tubes, Types DE 201A, DE 199.

Important for Jobbers and Dealers

Pending increased production from the new Cleveland factory, the demand for Myers Tubes has accumulated, and orders will be filled in sequence. National Advertising is being released in proportion to the enlargement of the plant. To enjoy the profits that can be had from the prestige of Myers Tubes orders should be anticipated as fully as possible to insure deliveries as wanted.

List Price, All Types, $2.50 Each

Myers Radio Tube Corporation

Office and Factory, 1890 East 40th Street, Cleveland, Ohio

Fig. 28. Previous page. One of the first display ads for the Myers Radio Tube Corporation made in Cleveland was placed in the *Cleveland Plain Dealer* on Jan. 12, 1926.

Fig. 29. The new singled-ended tubes made by the Myers Radio Tube Corporation in Cleveland featured a standard four-pin base. (Joe Knight collection)

Tubes" designated Type DE201A and DE 199. This ad is one of the few where the aging double-ended RAC-3 tube was given new type designations. An example of one of the new single-ended Myers tubes with a standard base is shown in Fig. 29.

A message for jobbers and dealers appearing at the bottom of this ad indicated that the plant was not operating at full capacity and that national advertising had not yet begun: "Pending increased production from the new Cleveland factory, the demand for Myers tubes has accumulated, and orders will be filled in sequence. National advertising is being released in proportion to the enlargement of the plant." Apparently the plant output had increased by March 1926 because a significant national advertising campaign

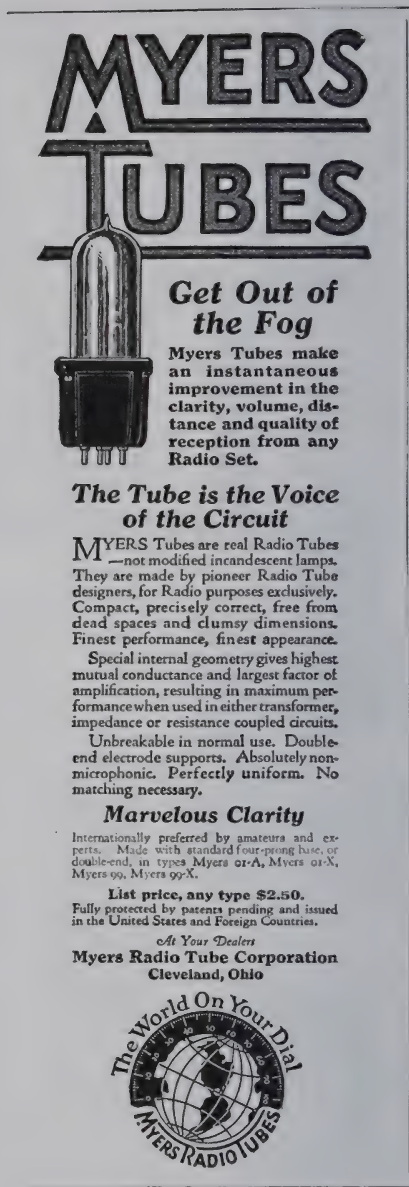


Fig. 30. Myers Radio Tube Corp. began a significant national advertising campaign in March 1926 with ads such as this one appearing in *Radio News* and other radio magazines, most notably *Radio, Popular Radio,* and *QST.* (*Radio News*, Mar. 1926, p.1368)

began that month with ads appearing simultaneously in various nationally distributed magazines, most notably *Radio News, Radio, Popular Radio,* and *QST* (see Fig. 30).[74] Ads also appeared in *Radio Broadcast* beginning with the April issue.

Three different ads appeared between March and June 1926 with tag lines such as: "Get out of the Fog…The Tube is the Voice of the Circuit," "Seven Years of Superiority…Get the World on Your Dial With Myers Tubes," and "Stop Shifting Tubes…Don't Guess—Don't Match." In March and April, the tubes were offered for purchase "At Your Dealers," but in May, tubes were offered "At your dealers, or we will ship, postpaid." Unfortunately for the customer, no company address was given for mail orders in these ads. The ads offered four tube types made with either four prong and double-ended bases: the Myers 01A, Myers 01X, Myers 99, and Myers 99X. All tubes were priced at $2.50 in March, but in succeeding months, the price of the tubes dropped to $2.00 for the Type 01 and $2.25 for the Type 99.

General Electric Sues Myers Radio Tube Corp.

The advertising campaign did not last very long because the ads virtually disappeared after the May issues of these magazines just as suddenly as they had appeared in March. There was a single ad placed in the June issue of *Radio,* apparently the very last ad place by the Myers Radio Tube Corporation.[75] The sudden suspension of ads in the national magazines was a result of General Electric filing suit on April 15, 1926 alleging that Myers Radio Tube Corp. was infringing on the Langmuir reissue patent No. 15,278 entitled "Electron Discharge Apparatus." The filing of this suit was briefly announced in the *Official Gazette* of the U.S. Patent Office: "Re: 15,278, I. Langmuir, Electron-discharge apparatus, suit filed Apr. 15, 1926, D. C. N. D. Ohio (E. Div.), Doc. 1821, General Electric Co. v. Myers Radio Tube Corp., et. al."[76]

The reissue patent 15,278 mentioned in this announcement relates to a particular construction and arrangement of elements within a thermionic vacuum tube whereby the cathode and grid are supported and yet insulated by the same mounting. According to the transcript of the FTC hearings, the examiner asserted: "The Radio Corporation group…proceeded against them [Myers Radio Tube Corp.] on the patent involving the use of very fine wire, so fine it was not able to stand by itself and had to be supported."[77] Apparently the Myers Radio Tube Corp. used the patented design in its new 01 and 99 tubes with standard bases.

Myers testified at the FTC hearings that he had not received $9,000 in royalties that the Myers Company in the U.S. was obligated to pay him and that he also sued the Company to collect his royalties.[78] He further he testified that his suit precipitated the bankruptcy that soon followed. According to the examiner in the FTC hearings, the Myers Radio Tube Corp. submitted to a consent decree and went bankrupt. However, it seems unlikely

that the $9,000 Myers testified he was due—a small amount compared to the investment in the Myers Radio Tube factory—would have actually precipitated the bankruptcy. It is more likely that the bankruptcy was caused by a blatant infringement of the Langmuir patent, which would have prevented the Company from manufacturing and selling its new standard-based tubes in lieu of its obsolete double-ended tubes.

Regardless of its proximate cause, the resulting bankruptcy can be confirmed by a notice placed in the Dec. 30, 1926 edition of the *Cleveland Plain Dealer* by one Frank H Miner, the court-appointed receiver for the Myers Radio Tube Corporation. The notice advertised the property, rights, and assets of the Myers Radio Tube Corporation appraised at $41,458.50 were to be liquidated on January 5, 1927.[79] Shortly thereafter, a number of Myers Type UX-201-A tubes were offered for sale in an ad placed in the *Boston Herald* in March of 1927 by Williams Radio Stores claiming: "We have been appointed exclusive franchise dealers for Myers Tubes" (see Fig. 31).[80] It is likely that these tubes were the ones sold by Frank Miner in January as part of the court-approved liquidation plan.

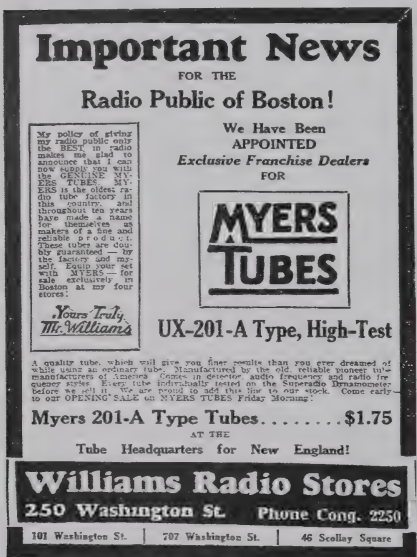


Fig. 31. Some of the Myers Type UX-201-A tubes that were most likely sold in the receiver's auction appeared in an ad placed in the *Boston Herald* in March of 1927 by Williams Radio Stores claiming: "We have been appointed exclusive franchise dealers for Myers Tubes." (*Boston Herald*, Mar. 11, 1927, p. 19)

The final ruling by the court on the fate on the Myers Company was memorialized in a short notice dated June 29, 1927 appearing three months later in the August 1927 edition of the *U.S. Patent Office Gazette* tersely stating that the Langmuir patent was "held valid and infringed" by the Myers Radio Tube Corp.[81] No other references to this lawsuit could be found in U.S. legal references such as the *Federal Reporter* and *Federal Supplement*, which supports the FTC examiner's assertion that the company submitted to a consent decree.

The pronouncement by the court dated June 29, 1927 ended the colorful saga of Elman B. Myers as a tube maker and the four distinctly different Myers companies with which his name was associated—Radio Lamp Corp., a New York corporation; Radio Audion Co. of Jersey City, New Jersey, a Delaware corporation; E. B. Myers, Co., Ltd. of Montreal, Canada; and Myers Radio

Tube Corp. of Cleveland, Ohio, a Delaware corporation. The development and sale of three-element tubes by Myers and these four companies spanned an 8½-year period from the incorporation of the Radio Lamp Corp. in November of 1918 to the time Myers Radio Tube Corp. ceased operations in mid-1926.

ENDNOTES

1. E. P. Wenaas, "E T. Cunningham and the Vacuum-Tube Tangle," *The AWA Review*, Vol. 25, 2012, pp. 185-251.
2. Certificate of Incorporation of Radio Lamp Corporation, Book 696, Page 620, State of New York, Office of the Secretary of State.
3. Certificate of Incorporation of Radio Audion Company, State of Delaware, Secretary of State, Division of Corporations, 09-04-1920. The incorporation document was signed on Sept. 3, 1920 and recorded on Sept. 4, 1920.
4. American Telephone and Telegraph Co. v. Radio Audion Co. et al. (District Court. D. Delaware. April 22, 1922)," Federal Reporter (West Publishing Co., St. Paul) Vol. 281, Sept.-Oct. 1922, pp. 200-205.
5. "Radio Case, Federal Trade Commission vs. General Electric Company, American Telephone & Telegraph Company, Western Electric Company Inc., Westinghouse Electric & Manufacturing Company, The International Radio Telegraph Company, United Fruit Company, Wireless Specialty Apparatus Company, and Radio Corporation of America," (Sidney C. Ormaby Company, 217 Broadway, New York, 1928) pp. 3708-3800. This document is referred to hereafter as "FTC Hearings, 1928."
6. "Real Benefactors and Alleged Inventors," *The Wireless Age*, Vol. 4, No. 9, June 1917, p. 617.
7. Government Control of Radio Communication, Hearing before the Committee on Merchant Marine and Fisheries, House of Representatives, 65 Congress, Third Session on H.R. 13159, Dec. 12, 13, 17, 18, 19, 1918 (Government Printing Office, Washington, 1919) p. 349.
8. "Fined for Breaking into Station," *The Wireless Age*, Vol. 4, No. 12, Sept. 1917, p. 874.
9. "Elman Myers' Resumé," *The Tube Collector*, Vol. 10, No. 2, April 2008, pp. 17-20.
10. FTC Hearings, 1928, pp. 3708-3800.
11. E. B. Myers' Testimony, FTC Hearings, 1928, p 3774.
12. R. Brown, "War-Time Development of Vacuum Tubes, *Electrical World*, Vol. 73, No. 8, Feb. 22, 1919, p. 358-363; E. B. Craft and E. H. Colpitts, "Radio Telephony—II," *Scientific American*, Supplement No. 2260, April 26, 1919, pp. 268-281; N. H. Slaughter, "Wireless Telephony," J. *Amer. Soc. of Naval Engrs.*, Vol. 32, 1920, pp. 134-146.
13. E. B. Myers, "An Interview with the Inventor," *Radio News*, Vol. 4, No. 1, July 1922, pp. 65,104-105.
14. Myers testified at the FTC hearings that he was employed at the West Street facility in New York (p. 3714), but he also wrote in his resume that his responsibilities were "to supervise the construction of a mass production Audion tube manufacturing facility and acquaint the staff with the knowledge required to operate it." Since the vacuum tubes were mass produced at the Hawthorne Works in suburban Chicago beginning in early 1918, Myers could have either

been assigned there for an extended period of time or travelled to Chicago on a regular basis like many of the engineers from West Street. According to the Western Electric News (Feb. 1919, p. 5), radio technologies developed in the laboratories at West Street during 1918 were transferred to Hawthorne by train: "As soon as a detail was decided upon, it was rushed out to Hawthorne and work on the tools started. The twenty-hour trains between New York and Chicago were well patronized during this period." It is also possible he had little to do with increasing tube production at Western Electric during the war, as he claimed. In either event, he was clearly employed at Western Electric for most of 1918.

15. "New Incorporations," *The New York Times*, Nov. 27, 1918, p. 17.
16. E. L. Chao and K. P. Utgoff, "100 Years of U.S. Consumer Spending, Data for the Nation, New York City and Boston, (Bureau of Labor Statistics, Office of Publications and Special Studies, Report 991, May 2006) pp. 9-13; on-line version at http://www.bls.gov/opub/uscs/
17. "DeForest–Radio Lamp Corporation Immunity Agreement of November 25, 1919," Tyne Library, Licensing Agreements, File 20.
18. E. P. Wenaas, *The AWA Review*, Vol. 25, pp. 212-213.
19. E. T. Cunningham Testimony, FTC Hearings, 1928, p. 2000. Cunningham testified that in 1919 he sold 7,000 tubes, and in 1920 he sold 15,000-20,000 tubes. The best estimate for the midpoint in time (December 1919) would be to total the amount for the first two years and divide by 24, which amounts to 900 to 1100 tubes sold in December 1919.
20. E. B. Myers Testimony, FTC Hearings, 1928, p. 3754.
21. W. Pelzer Affidavit, FTC Hearings, 1928, p. 3755.
22. "DeForest Radio Telephone & Telegraph Co. vs. Elman B. Myers," Letter from Knight, Boland, Hutchinson & Christian to Sheffield & Betts, dtd. July 23, 1921, Tyne papers, Vol. 2, p. 15.
23. Two identical letters from Sheffield & Betts, one addressed to Mr. Elman B. Myers and the other to Radio Lamp Corporation, both dtd May 4, 1920, Tyne papers, Radio Audion Litigation, Vol. 1, pp. 2 & 3.
24 The absence of a street address at the top of letters in the files of RCA correspondence is highly unusual. These two letters are the only two out of hundreds of letters from the RCA files that are missing the street addresses.
25. Verona, NJ as it appeared at the time Myers lived there is described in the book by Robert L. Williams, *Old Verona*, (Arcadia Publishing, 1998).
26. J. C. Gorman, "The Thunder of Our Heart Throbs," *Popular Radio*, Vol. 1, No. 2, June, 1922, p.136.
27. Letter from Sheffield & Betts to RCA Attorney Ira Adams dated June 18, 1920, Tyne papers, Radio Audion Litigation, Vol. 1, p. 4.
28. The United Synthetic Drug Corporation (USDC) was known to occupy 90 Oakland Avenue in Jersey City until Aug. 1920: American Druggist, USDC display ad with 90 Oakland Ave. address, Aug. 1920, p. 81; USDC display ad announc-

ing its new post-Oakland-Ave. address, *American Druggist*, Sept. 1920, p. 78.

29. Display Ad, *Science and Invention*, Vol. 8, No. 8, Dec. 1920, p. 896.

30. Memo from H. C. Gawler to E. E. Bucher dated 5/11/21, Tyne papers, Radio Audion Litigation, Vol. 1, p. 23. The following note written by Bucher appears on the memo: "Mr. Sarnoff, You no doubt will be interested in reading this before I pass it on to Mr. Adams. EEB." Sarnoff then wrote on the memo: "noted, pls [please] pass to Mr. Adams."

31. Letter from Ira Adams to Mr. A. G. Davis, dtd. July 20, 1921, Tyne papers, Radio Audion Litigation, Vol. 2, pp. 13-14.

32 Letter from Sheffield & Betts to Ira Adams dtd. Sept. 29, 1921, Tyne papers, Radio Audion Litigation, Vol. 2, p. 31.

33. The Willis-Graham Act passed in 1921 exempted AT&T from the Sherman Antitrust Act of 1890 and effectively repealed the so-called Kingsbury Commitment, in which AT&T had agreed to refrain from buying competing telephone companies. This Act allowed AT&T to legally create a monopoly and acquire independent telephone companies whether or not they competed with AT&T upon the approval of regulatory agencies, primarily the Interstate Commerce Commission (ICC)—and without Justice Department review. AT&T planned to buy up numerous independents to achieve its goal of creating a monopoly in telephone service nationwide. AT&T had little interest in jeopardizing government approvals required for the purchase of these companies by generating bad publicity as plaintiffs with RCA and GE in litigation against a small company to enforce RCA's monopoly in vacuum tubes—something that the radio industry and public were very much against. By maintaining a good relationship with the ICC and state/local governments, AT&T was able to acquire approximately 223 independent telephone companies between 1921 and 1924 with ICC approval." 34. Letter from Ira Adams to Messrs. Sheffield & Betts dtd. Jan. 28, 1922, Tyne papers, Radio Audion Litigation, Vol. 3, p 9.

35. Radio Corporation of America v. Radio Audion Co. (District Court. D. Delaware. Jan 20, 1922), *Federal Reporter*, Vol. 278, April-May 1922, pp. 628-629.

36. E. P. Wenaas, *The AWA Review*, Vol. 25.

37. American Telephone & Telegraph Co. v. Radio Audion Co, et. al.," *Federal Reporter*, Vol. 281, pp. 200-205.

38. K. B. Warner, "Radio Frequency Amplification at Amateur Wave Lengths," *QST*, Vol. 6, No. 2, Sept. 1922, p. 14

39. "Selection of Vacuum Tubes," *Radio News*, Vol. 5, No. 3, Sept. 1923, p. 272.

40. Letter from John W. Peters to David Sarnoff dtd. July 27, 1922, Tyne Library, Radio Audion Litigation vol. 3, p. 36.

41. "Radio Corporation of America v. Radio Audion Co. (District Court, D. Delaware. Nov. 4, 1922)," *Federal Reporter*, Vol. 284, Dec. 1922-Feb. 1923, pp. 581-585.

42. "Radio Corporation of America v. Radio Audion Co.," *Federal Reporter*, Vol. 284, p. 1020.

43. Credit Report from R. G. Dunn & Co. dtd. 1/17/24, Tyne papers, Radio Audion Litigation, Vol. 5, p. 7.

44. "American Telephone and Telegraph Co. v. Radio Audion Co. (District Court.

D. Delaware, May 16, 1925)," *Federal Reporter*, 2nd Edition, Vol. 5, pp. 535-537.
45. Ibid., p. 537.
46. "On Accounting Before the Court, Brief for Plaintiff" AT&T v. Radio Audion Co., District Court of the United States for the District of Delaware, undated.
47. G. Tyne, *Saga of the Vacuum Tube*, p. 334. The three sentences are reproduced here in the order they appeared in Saga, although they do not appear contiguously.
48. Why Radio Audion discontinued its national advertising after August 1922 is not clear—perhaps it decided to wait for the appellate court decision expected in late 1922 on its appeal of the injunction granted in April 1922 by Judge Morris in the AT&T suit.
49. Bill Condon, Bill's Vintage Tube Site, http://www.bill01a.com/tubephotos/bat-rac3.htm; Radiomuseum, http://www.radiomuseum.org/tubes/tube_rac3.html; N6JV's Transmitting Tube Museum, http://home.comcast.net/~n6jv/rac3.html.
50. "Bankruptcy Proceedings," *New York Times*, April 11, 1923, p.27.
51. *Sessional Papers of The Dominion of Canada*, Parliament of Canada, Vol. 61, Issue 4, 1925, p. 62.
52. Canadian Intellectual Property Office, http://brevets-patents.ic.gc.ca/
53. Display Ad, *Radio* (Canada), Vol. 6, No. 5, Sept. 1923, front cover.
54. "Making Radio tubes in Canadian Factory, *The Electrical News*, Vol. 3, No. 24, Dec. 15, 1923, p. 46.
55. "Myers Display Ad," *Wireless Age,*" Vol. 11, No. 4, March 1924, p. 87.
56. Jerry Vanicek, private communication.
57. "Myers Display Ad," *QST*, Vol. VIII, No. 5, Dec. 1924, p. 66.
58. "A New Audion," *Boston Herald*, Aug. 6, 1922, p. 9.
59. Display Ad, *Popular Radio*, Vol. III, No. 1, Jan. 1923, p. 28.
60. Display Ad, "Myers Radio Corporation," *The Magazine Wall Street*, Vol. 35, No. 9, Feb. 28, 1925, p. 767.
61. "Myers' Tubes Selling in England," *Electrical News*, Vol. 33, Jan.-June, 1924, p. 48.
62. Display Ad, *Experimental Wireless & The Wireless Engineer*, Vol. I, No. 12, Sept. 1924, p. 12.
63. "The Myers Valve," *The Wireless World and Radio Review*, No. 19, Vol. XIII, Feb. 6, 1924, p. 390.
64. "Radio Coach 6ZZ," *The Wireless World and Radio Review*, Vol. XIV, July 16, 1924, pp. 446-451.
65. "Delaware Charters", *The New York Times*, Jan. 27, 1925, p. 35.
66. *New York Commercial*, Feb. 2, 1925, p.5.
67. *The Cumulative Daley Digest of Corporation News*, First Bi-Monthly Number, Jan.–Feb. 1925, p. 510.
68. "Myers Radio Corporation," *Magazine of Wall Street*, Vol. 35, No. 9, Feb. 28, 1925, p. 767.
69. The New York Curb, also known as the American Stock Exchange, was once a market place for securities not reputable enough to be listed on the New York Stock Exchange.
70. See for example, New York Commercial, Feb. 2, 1925, p. 5.
71. E. B. Myers Testimony, FTC Hearings, 1928, p. 3715.
72. "Pioneer Vacuum Tube Factory Comes to City," *Cleveland Plain Dealer*, Nov. 1, 1925, p. 8.

73. For example see *Radio World*, "Myers to Manufacture Tubes in Cleveland," Vol. 8, No. 8, Nov. 14, 1925, p. 22; Sunday *Oregonian Portland*, Nov. 8, 1925, p. 9.
74. Display Ad, *Radio News*, Vol. 17, No. 9, March 1926, p.1368.
75. Display Ad, *Radio*, Vol. VIII, No. 6, June 1926, p. 62.
76. "Re. 15,278, I. Langmuir, Electron-discharge Apparatus," *Official Gazette of the U.S. Patent Office*, Vol. 347, 1926, p. 544.
77. FTC Hearings, 1928, p. 3769. Note that Tyne incorrectly stated the following on p. 334 of Saga: "RCA sued them [Myers radio Tube Corp.] for back royalties and they went bankrupt." Tyne was apparently unaware of who brought the suit, and assumed it was RCA from the examiners question to Myers, "The Radio Corporation group also brought suit against them?"—to which Myers answered "I guess so." General Electric, who was part of the Radio Corporation group, actually brought the suit—not RCA.
78. FTC Hearings, 1928, pp. 3769, 3774-5.
79. "Notice of Receiver's Sale," *Cleveland Plain Dealer*, Dec. 30, 1926, p. 18.
80. Display Ad, *Boston Herald*, March 11, 1927, p. 19.
81. "Re. 15,278, I. Langmuir, Electron-discharge Apparatus," *Official Gazette of the U.S. Patent Office*, Vol. 361, 1927, p. 664.

Acknowledgements

I would like to thank Jerry Vanicek profusely for providing artifacts, photographs, and for his sage advice that improved this manuscript considerably. I would also like to thank Joe Knight for allowing me to study and photograph a number of artifacts from his excellent collection, and for his critical review of this manuscript. Finally, I would like to thank Stew Oliver for providing photographs of tubes and other artifacts from his collection.

ABOUT THE AUHOR

Eric P. Wenaas has had a lifelong passion for antique radios beginning with his first Radiola and crystal set given to him as a young man growing up in Chicago by family friends. He experimented with radio devices and repaired radios and televisions as a hobby while in high school, and went on to study electrical engineering at Purdue University, graduating with B.S. and M.S. degrees in Electrical Engineering. He then went to the State University of New York (SUNY) at Buffalo where he earned a Ph.D. degree in Interdisciplinary Studies in the School of Engineering. After graduating, he spent most of his career at Jaycor, a defense company in Southern California—first as an engineer and later as the President and Chief Executive Officer.

Upon his retirement in 2002, he set out to research the early days of wireless and document interesting historical vignettes based on original documents of the era. He has written numerous articles for the *AWA Review*, the *AWA Journal* and the *Antique Radio Classified*, and published a critically acclaimed book in 2007, *Radiola: The Golden Age of RCA - 1919-1929*, covering the early history of RCA—including

the formative years of the Marconi Telegraph Company of America. For this work, he received the AWA Houck Award for Documentation in 2007. He received a second Houck Award in 2012 for His Work in Preserving the History of the Radiola by his Outstanding Collection. Dr. Wenaas is a lifetime member of the AWA and a past member of both the IEEE and the American Physical Society. He resides in Southern California and continues to enjoy collecting radios, researching the early days of wireless and writing articles.

Eric Wenaas

APPENDIX A - Sarnoff letter to Dealers

Telephone Co secured injunction April 29/22 on Audion Patent

(Copy)

World Wide
Wireless

RADIO CORPORATION

DAVID SARNOFF
GENERAL MANAGER

OF AMERICA

233 Broadway

NEW YORK

July 1st, 1922

INFORMATION REGARDING RADIO PATENT SITUATION

Following the great demand for Radio receivers and accessories, there have appeared in various parts of the country vacuum tubes of a very inferior quality which infringe upon patent rights owned by the Radio Corporation of America, under United States Letters Patent to Fleming No. 803,684, dated November 7, 1905 and DeForest Patents Nos.841,387 and 879,532. The first of these DeForest Patents does not expire until January 15, 1924, and the latter does not expire until February 18, 1925.

All three of these patents have been sustained as valid by the United States Courts and control broadly all vacuum tubes used as detectors, amplifiers, oscillators or "oscillions" in radio work.

The Radio Corporation of America has been vigorously prosecuting suits to protect its rights under these patents and intends to continue so to do.

Patent infringement suits have been instituted and injunctions have already been obtained against the following concerns:

Moorhead Laboratories, Inc.,
Atlantic-Pacific Radio Supplies Co.

of San Francisco, California, manufacturers and distributors of the so-called "Moorhead" tubes.

Benjamin Lakow,
Samuel Lakow,
The Lowe Motor Supplies Company

of New York City.

APPENDIX A

The Radio Audion Co. of Jersey City, N.J.
Conrad Shickerling of Union Hill, N.J.,
Alfred H. Scheff of New York City,
Atlantic Communication Co. of New York,
Universal Radio Manufacturing Co. of Elmira, N.Y.,
Bison Electrical Co. of Buffalo, N.Y.,
F.B. Chambers & Co., Philadelphia, Pa.,
Radio Apparatus Company, Philadelphia, Pa.,
Alexander Lolass, N. Y. City,
American Electro Technical Appliance Co.,of N.Y.City,
Eugene Dynner, New York City,
S. C. Evans, Cleveland, Ohio,
H. S. Wireless Company, Brooklyn, N.Y.
Haloun Radio Company, San Francisco, Calif.,
Haller-Cunningham Electric Co.,San Francisco, Calif.
International Electric Co., New York City,
Liberty Radio Apparatus Co., Pottstown, Pa.,
Herman Lubinsky, Newark, N.J.,
Leo J. Meyberg and L. J.Meyberg Co., San Francisco, Calif.
The New Era Lamp Company, South Orange, N.J.,
Newman-Stern Company, Cleveland, Ohio,
Radio Equipment Company, Philadelphia, Pa.

The Radio Corporation of America therefore issues this notice to manufacturers, distributors, jobbers and dealers, to cease the manufacture, or the sale, or distribution of vacuum tubes which infringe the above mentioned patents.

Unauthorized distributing or selling of a patented device wholly independent of manufacturing, is just as much an infringement of the patent as the manufacturing itself, and any seller is separately liable to suits for accounting for damages or profits in addition to an injunction.

For their own protection,the distributors, jobbers and dealers who without authority of the holders of the above patents may yet be offering for sale vacuum tubes for radio work, should require a guarantee from the manufacturer from whom they purchase these devices, holding them harmless in case of damage suits arising through their distribution and sale of vacuum tubes which infringe the above mentioned patents.

Vacuum tubes are now available through the distributors of the Radio Corporation of America in large quantities which are sold under the above-mentioned patents and can be readily identified by the trade names and marks of that Company,the vacuum tubes being known as the "Radiotron".

RADIO CORPORATION OF AMERICA,
233 Broadway,
New York City.

APPENDIX B

Appendix B: A Retrospective of Myers Company Artifacts

A selection of surviving artifacts from the following three companies associated with Elman Myers is presented here: Radio Audion Co. of Jersey City (Radio Audion), E. B. Myers Co., Ltd. of Canada (E. B. Myers), and Myers Radio Tube Corp. of Cleveland (Myers of Cleveland). The artifacts consist of vacuum tubes, mounting receptacle and clips, tube cartons, instruction inserts, and factory-made receivers designed to use double-ended RAC-3 audions.

Fig. B1. Radio Audion RAC-3 Audions: Audions with three different markings have been observed: "Myers Type RAC-3 Audion" with the company name and address and a serial number on the opposite side (top), "Myers Audion" with the date of manufacture on the opposite side (middle), "Myers Audion" as the middle but with a paper label warning that the tube was not be used as a detector (lower). (Stew Oliver and Eric Wenaas collections)

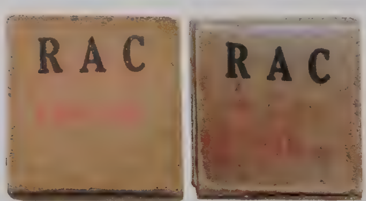


Fig. B2. Radio Audion Carton Lids: Both carton lids were printed with the company initials RAC and then one lid was overstamped to identify the actual contents—for example "Myers Audion" for an audion (left) and A.F. Amp. Coil for the audio frequency choke coil (right). (Stew Oliver and Eric Wenaas collections)

Fig. B3. Radio Audion Cartons: Cartons with the Radio Audion name and address (top) were used not only for RAC-3 audions, but also for RF transformers and audio frequency amplifier coils, as indicated by the printing on the opposite side (middle). A warning label was affixed to cartons containing audions beginning in late January or early February of 1922 to proscribe their use as detectors (lower).

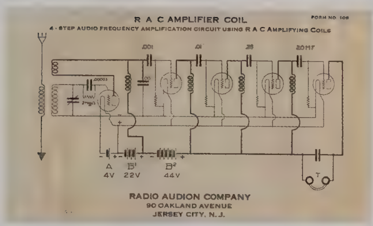


Fig. B4. Radio Audio Carton AF Coil Insert: This insert with a schematic diagram featuring the audio-frequency choke coils was placed in the cartons containing the RAC amplifier coils.

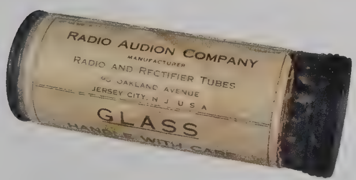


Fig. B5. Radio Audion Mailing Tube: This mailing tube dated 1-20-21 was one of the earliest to be used in Radio Audion's mail order business.

Fig. B6. Radio Audion Mailing Tube Insert: These three panels from a six-panel insert entitled "RAC-3 Audion and Receptacle" found in a Radio Audion mailer show the RAC-3 audion for sale at $3.50 and the receptacle for sale at $1.00.

Fig. B7 Radio Audion Receptacle: Radio Audion sold this receptacle for holding its audions with the recommendation that "all audions should be mounted in the vertical position to avoid sagging of the filament."

Fig. B8. Industrial Radio Service Co. Baby Ultra Receiver: Industrial Radio Service of Saginaw, MI manufactured a line of radio receiving equipment including this Baby Ultra Type 400 receiver, all of which were designed exclusively for RAC-3 audions held by Radio Audion mounting clips. (Courtesy of AWA Museum)

Fig. B9. Industrial Radio Service Co. Ad: This ad identifies the four-audion receiver shown in the previous figure as a "Baby Ultra Type 400" manufactured by Industrial Radio Service. (*Radio Digest*, Vol. 3, Dec. 1922, p. 14)

Fig. B10. Industrial Radio Service Co. Ultra Receiver: This Ultra Type 401 receiver using six RAC-3 audions was also advertised in the same issue of *Radio Digest* (Dec. 1922, p. 7). (Courtesy of AWA Museum)

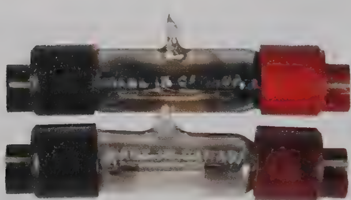
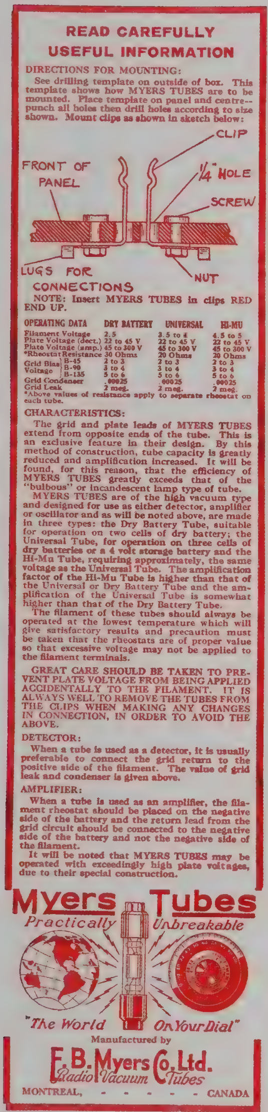


Fig. B11. E. B. Myers Tubes: Two types of E. B. Myers tubes have been observed, one with a "silvered" getter coating on the glass interior (upper) and one without (lower). The only printed phrase observed on both of these tube types is "Made in Canada."

Fig. B12. E. B. Myers Brown Tube Cartons: Two types of brown tube cartons have been observed, one for the Universal tube and the other for the Dry-Cell type.

Fig. B13. E. B. Myers Blue Tube Cartons: Two types of blue tube cartons have been observed, one for the Universal audion and one for the Hi-Mu audion. (Joe Knight and Eric Wenaas collections)

Fig. B14. E. B. Myers Mailing Tube: this mailing tube is virtually identical to the one used by Radio Audion.



READ CAREFULLY
USEFUL INFORMATION

DIRECTIONS FOR MOUNTING:

See drilling template on outside of box. This template shows how MYERS TUBES are to be mounted. Place template on panel and centre--punch all holes then drill holes according to size shown. Mount clips as shown in sketch below:

NOTE: Insert MYERS TUBES in clips RED END UP.

OPERATING DATA		DRY BATTERY	UNIVERSAL	HI-MU
Filament Voltage		2.5	3.5 to 4	4.5 to 5
Plate Voltage (dect.)		22 to 45 V	22 to 45 V	22 to 45 V
Plate Voltage (amp.)		45 to 300 V	45 to 300 V	45 to 300 V
*Rheostat Resistance		30 Ohms	20 Ohms	20 Ohms
Grid Bias Voltage	B-45	2 to 3	2 to 3	2 to 3
	B-90	3 to 4	3 to 4	3 to 4
	B-135	5 to 6	5 to 6	5 to 6
Grid Condenser		.00025	.00025	.00025
Grid Leak		2 meg.	2 meg.	2 meg.

*Above values of resistance apply to separate rheostat on each tube.

CHARACTERISTICS:

The grid and plate leads of MYERS TUBES extend from opposite ends of the tube. This is an exclusive feature in their design. By this method of construction, tube capacity is greatly reduced and amplification increased. It will be found, for this reason, that the efficiency of MYERS TUBES greatly exceeds that of the "bulbous" or incandescent lamp type of tube.

MYERS TUBES are of the high vacuum type and designed for use as either detector, amplifier or oscillator and as will be noted above, are made in three types: the Dry Battery Tube, suitable for operation on two cells of dry battery; the Universal Tube, for operation on three cells of dry batteries or a 4 volt storage battery and the Hi-Mu Tube, requiring approximately, the same voltage as the Universal Tube. The amplification factor of the Hi-Mu Tube is higher than that of the Universal or Dry Battery Tube and the amplification of the Universal Tube is somewhat higher than that of the Dry Battery Tube.

The filament of these tubes should always be operated at the lowest temperature which will give satisfactory results and precaution must be taken that the rheostats are of proper value so that excessive voltage may not be applied to the filament terminals.

GREAT CARE SHOULD BE TAKEN TO PREVENT PLATE VOLTAGE FROM BEING APPLIED ACCIDENTALLY TO THE FILAMENT. IT IS ALWAYS WELL TO REMOVE THE TUBES FROM THE CLIPS WHEN MAKING ANY CHANGES IN CONNECTION, IN ORDER TO AVOID THE ABOVE.

DETECTOR:

When a tube is used as a detector, it is usually preferable to connect the grid return to the positive side of the filament. The value of grid leak and condenser is given above.

AMPLIFIER:

When a tube is used as an amplifier, the filament rheostat should be placed on the negative side of the battery and the return lead from the grid circuit should be connected to the negative side of the battery and not the negative side of the filament.

It will be noted that MYERS TUBES may be operated with exceedingly high plate voltages, due to their special construction.

Fig. B15. E. B. Myers Blue Carton Insert (left): This insert found in a blue tube carton lists three tube types—Universal, Dry Battery, and Hi-Mu—suggesting that the company also made a blue carton with a "dry battery" label.

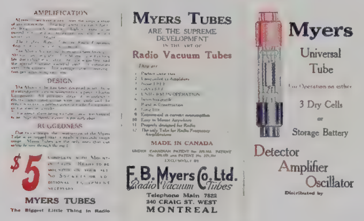


Fig. B16. E. B. Myers Mailing Tube Insert: This insert for a Universal Audion was found inside the mailing tube appearing in the previous figure.

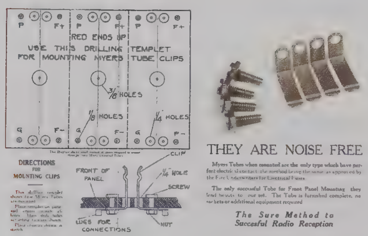
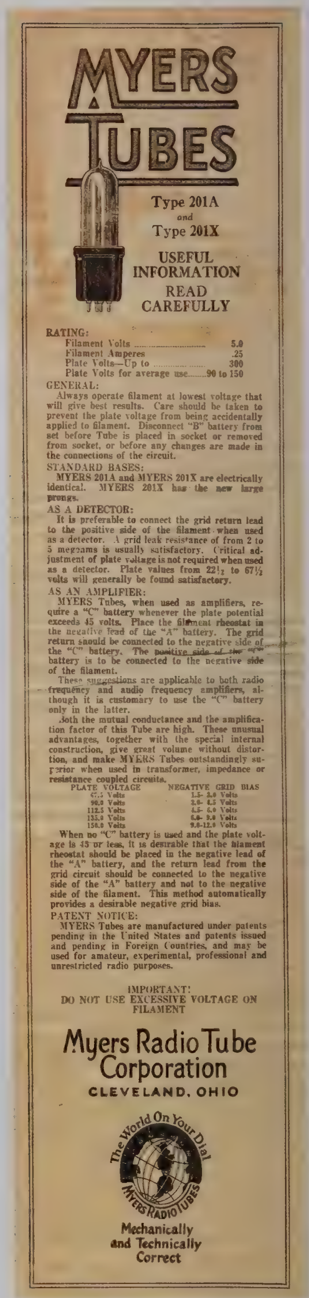


Fig. B17. E. B. Myers Mounting Clips: These mounting clips were found in the bottom of an E. B. Myers mailing tube; the diagram on the back of the insert found in the mailing tube has directions for mounting the clips, and it also shows how close the tubes can be mounted to each other.

Fig. B18. Myers of Cleveland Tube: This 201A tube with the small prongs was electrically equivalent to the 201X tube with larger prongs. (Joe Knight Collection)

Fig. B19. Myers of Cleveland Carton: Tube cartons printed by Myers of Cleveland advertised that "all types" of its tubes came with both "standard base" and "double end" configurations. (Joe Knight Collection)

Fig. B20. Myers of Cleveland Carton Insert (right): This insert for both Type 201A and Type 201X tubes had instructions for wiring the grid, and provided recommended ranges of plate voltages for the tubes when used as a detector or an amplifier.



MYERS TUBES

Type 201A
and
Type 201X

USEFUL INFORMATION
READ CAREFULLY

RATING:

Filament Volts	5.0
Filament Amperes	.25
Plate Volts—Up to	300
Plate Volts for average use	90 to 150

GENERAL:
Always operate filament at lowest voltage that will give best results. Care should be taken to prevent the plate voltage from being accidentally applied to filament. Disconnect "B" battery from set before Tube is placed in socket or removed from socket, or before any changes are made in the connections of the circuit.

STANDARD BASES:
MYERS 201A and MYERS 201X are electrically identical. MYERS 201X has the new large prongs.

AS A DETECTOR:
It is preferable to connect the grid return lead to the positive side of the filament when used as a detector. A grid leak resistance of from 2 to 5 megoams is usually satisfactory. Critical adjustment of plate voltage is not required when used as a detector. Plate values from 22½ to 67½ volts will generally be found satisfactory.

AS AN AMPLIFIER:
MYERS Tubes, when used as amplifiers, require a "C" battery whenever the plate potential exceeds 45 volts. Place the filament rheostat in the negative lead of the "A" battery. The grid return should be connected to the negative side of the "C" battery. The ~~positive side of the "C"~~ battery is to be connected to the negative side of the filament.

These suggestions are applicable to both radio frequency and audio frequency amplifiers, although it is customary to use the "C" battery only in the latter.

Both the mutual conductance and the amplification factor of this Tube are high. These unusual advantages, together with the special internal construction, give great volume without distortion, and make MYERS Tubes outstandingly superior when used in transformer, impedance or resistance coupled circuits.

PLATE VOLTAGE	NEGATIVE GRID BIAS
67.5 Volts	1.5- 3.0 Volts
90.0 Volts	3.0- 4.5 Volts
112.5 Volts	4.5- 6.0 Volts
135.0 Volts	6.0- 9.0 Volts
150.0 Volts	9.0-12.0 Volts

When no "C" battery is used and the plate voltage is 45 or less, it is desirable that the filament rheostat should be placed in the negative lead of the "A" battery, and the return lead from the grid circuit should be connected to the negative side of the "A" battery and not to the negative side of the filament. This method automatically provides a desirable negative grid bias.

PATENT NOTICE:
MYERS Tubes are manufactured under patents pending in the United States and patents issued and pending in Foreign Countries, and may be used for amateur, experimental, professional and unrestricted radio purposes.

IMPORTANT:
DO NOT USE EXCESSIVE VOLTAGE ON FILAMENT

Myers Radio Tube Corporation
CLEVELAND, OHIO

The World On Your Dial
MYERS RADIO TUBES

Mechanically and Technically Correct

The First Heathkit, the O-1 Oscilloscope

and the series from O-1 through O-12

©2013 Erich E. Brueschke

ABSTRACT

The positive influence of Heathkits is well understood today but the first Heathkit, the 5-inch Oscilloscope, now called the 'O-1', is not well documented since only the instruction sheets and parts sheet were known to survive until recently. With the discovery of a complete O-1 for study, a better understanding of the development of the entire earlier Heathkit oscilloscope line, including oscilloscope size, design, components, and appearance is possible. The early dependence on surplus components progressed to changes required by availability of commercial parts while still maintaining low cost and acceptable commercial quality of the product. Heathkits went on to be the standard in electronic kits as well as a vehicle to train future radio amateurs, technicians, engineers, and scientists on how things work, the feel of how things are put together, as well as the joy of assembling something yourself and having it function. This article emphasizes the rapid comparative technical changes in the first few years of production of this model, as well as the first oscilloscope models called "red-face", through the O-9 model, and then through the charcoal grey models O-10 through the O-12, covering 1947 through 1959.

Edward Heath never made electronic kits, but he did sell airplane kits and parts. After his death in an airplane crash in 1931, the company was purchased by Howard E. Anthony in 1935. Howard E. Anthony later moved the company into surplus sales and became the driving force behind the development of Heathkit electronic kits. Heathkit closed its doors to kit production in 1992.

A brief history of Heathkits, the war surplus era, and early change as well as a database for all Heathkit items sold 1947-1956, except war surplus, is provided in my paper in the 2010 *AWA Review* (1). That paper references other contributors to the field, such as the excellent historical resource *Heathkit*

Nostalgia (Ref. 1, p. 102). Information provided on the Heathkit oscilloscopes was limited, especially on the very first Heathkit electronic kit, the 5-inch oscilloscope. This paper makes detailed comparisons between the O-1 through O-12 oscilloscopes, especially the first few years when change was more rapid. Many detailed circuit changes and changes in individual resistor and capacitor values are beyond the scope of this paper. Information on the earliest Heathkits is derived mainly from examples still in existence and advertisement materials sent out by Heathkit, the *Heath Flyers ('Flyers')*, and national publications such as *Radio News* which started as the *Radio Amateur News* in July 1919 Vol 1 No 1 (author's collection). This became *Radio News* in July 1920 Vol 2 No 1, and then *Radio and Television News* in September 1948. The first Heath ad for an oscilloscope kit was in the July 1947 *Radio News*.

This first Heathkit oscilloscope, did not have a model number on the panel and drawings referred to it only as a '5-inch Oscilloscope'. In the 2010 *AWA Review*, it was referred to as the O-1 (Ref. 1, p. 87) since the second model did have O-2 on the front panel under the CRT shield. Clearly the previous and earliest model could sensibly be referred to as the 'O-1'. I attempted to obtain information on the O-1 oscilloscope by advertising in *Antique Radio Classified* in February 2003 asking for an actual O-1 from 1947. This advertisement ran initially for two months and was extended for a total of six months. I had no response, even though I showed a magazine ad photo of the first oscilloscope from that era. At that time, I felt that an example of this first Heathkit was probably unobtainable.

THE FIRST HEATHKIT: THE 5-INCH OSCILLOSCOPE

The O-1 oscilloscope is the Holy Grail of Heathkit collecting. As of today, only two are known to exist. The one in the author's collection was provided to me by the important Heathkit collector Jay Whipple, Jr. of Illinois. Jay got his lead on the oscilloscope from Chuck Penson, renowned author of a book on Heathkit amateur products (2). The other known first Heathkit is in the collection Tom Peterson, the Director of the Antique Wireless Association. He built this oscilloscope kit himself in 1947 (3) and still has it.

The O-1 oscilloscope is important for a number of reasons, but significantly, because it represented the transition from Heath's World War Two surplus electronic sales to the vast Heath electronics kit empire that lasted over 50 years, with hundreds of different Heathkits serving as training and inspiration for countless amateurs, technicians, engineers, and scientists and which provided that joy of building a kit and having it function.

My paper on early Heathkits, which covered all Heathkits for 10 years (1, p. 81-113), suffered from the fact that I only had a small photograph of the O-1 obtained from the Dayton Hamfest on May 20, 2005, with no idea of its panel color, weight or even its dimensions.

Also, in the resource material, the interior of the oscilloscope was only partly shown in line drawings.

I felt it was important to track the early changes in the "O" series oscilloscopes to get a feel for innovation and shifting from surplus to commercial components and other changes. The first oscilloscopes were redesigned every few months, with new features, then yearly and near the end of the "O" models every two years. Except for the O-1, Heathkit provided schematics of all their oscilloscopes and most of their test equipment through *Flyers*, ads, and later in catalogs, at least through the O-12 in 1959. An exception may be the O-6 as described below. As well described by Chuck Penson (2), Heath continually improved construction details, instruction sheets and manuals throughout the years.

The change from oil filled filter capacitors to electrolytic capacitors most likely coincided with exhaustion of the huge quantity of the expensive (but cheap on the surplus market) oil filled capacitors available shortly after World War Two. Heath was able to hold the price of the 5-inch oscilloscope 0-1 through 0-6 to $39.50 by using war surplus components while making circuit improvements to enhance performance through to 1952, when the model O-7 price was changed to $43.50. In this paper, I have concentrated on *Radio News* and its successors as a source for development chronology since it was, by far, the most prolific publication of the era.

As I have previously written (1, p. 87), "With knowledge comes discrimination—the fundamental difference between the collector and the accumulator or hoarder." Collectors as well as historians want to know the origins, differences and variations as well as understand, to the extent they can with frequently incomplete information, the reasoning behind changes. Collectors and accumulators both make an important contribution to our understanding. In reality, many of us are a bit of both. This helps us preserve history.

SPECIFICS ON THE MODEL O-1 5-INCH OSCILLOSCOPE

The first Heath advertisement for an oscilloscope kit was nine lines of text in the July 1947 *Radio News* on page 122 at $39.50 (4). There was no photograph. The advertisement itself was titled "Heath Electronic Surplus Bargains." This advertisement probably ran in other publications at the same time (Penson, 2). The first photograph of the 5-inch oscilloscope was part of a full page advertisement, "The Best of Surplus" in the September 1947 *Radio News* on page 89 (5). A very nice advertisement in the November 1947 *Radio News* on page 102 showed a view of the parts making up the first 5-inch oscilloscope (6).

My own O-1 oscilloscope is shown in Figure 1. When you first see a Heathkit O-1 oscilloscope you are struck by the fact that it is taller (15" versus 13") and wider (10" versus 8½") than later Heathkit "O" models (Fig. 2). When

Fig. 1. The First Heathkit, the O-1 Oscilloscope, Showing the First Panel Colors, the Earliest Painted Brass Carrying Handle, and Unique Arrangement of Controls.

you try to lift it, at about 55 pounds, you are further impressed. A large, sealed power transformer with 18 ceramic stand-off terminals accounts for much of the weight (Fig. 3). I believe this transformer was a World War II surplus item and was not used in any subsequent oscilloscope design or any other Heathkit to my knowledge. The internal view is shown in Figure 4.

The O-1 has a unique set of binding posts not used in any other Heathkit (Fig. 6). Subsequently, Heath used standard hard rubber or Bakelite binding posts (Fig. 7) until they developed their own more universal binding post in 1952 (Fig. 8), capable of taking a variety

Fig. 2. Size Comparison of the Heathkit O-1 with the O-2 Oscilloscope.

of test leads including standard 4mm banana plugs. The O-1 schematic is shown in Figure 9.

- The O-1 has five tubes plus a war surplus 5BP1 5-inch CRT:
- Two 6SJ7 Amplifiers (horizontal and vertical)
- Two 5Y3 Rectifiers
- One 884 (or 6Q5 in later early models) Sweep Generator

The Sweep Frequency range of the O-1 is 15 Hz to 30 kHz. The parts list included with the kit shows an 8 position S-1 Sweep Frequency Control, and the schematic (Fig. 9), dated as revised September 8, 1947, shows a 6 position Sweep Frequency Control switch (S-1). The author's O-1 has a 7 position S-1 Sweep Frequency Control on the front panel. These are probably engineering development changes. The O-1 and all subsequent "O" series oscilloscopes had a 60 Hz test terminal mounted on the front panel. The lowest contemporary price I have found for the 5BP1 CRT was for $1.39 in a Lafayette Radio advertisement in the August 1948 *Radio News* (7). The last advertisement for the O-1 was in January 1948 (8). To my knowledge, no O-1 circuit diagram has surfaced in the Heathkit literature, *Flyers*, or advertisements other than that included with the O-1 kits and reproduced in this paper.

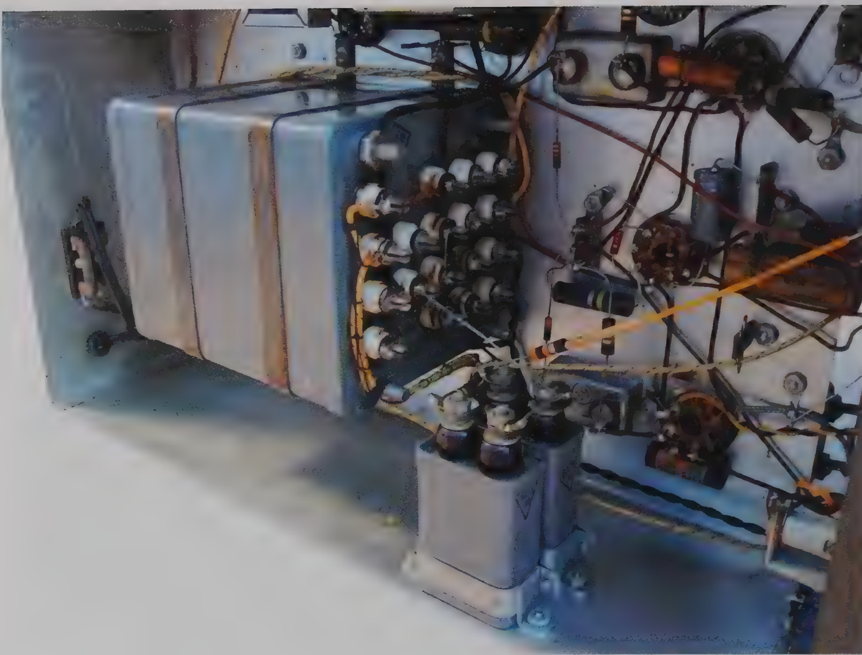


Fig. 3. Underside of O-1 Chassis Showing Large and Heavy Power Transformer with 18 Ceramic Stand-off Terminals.

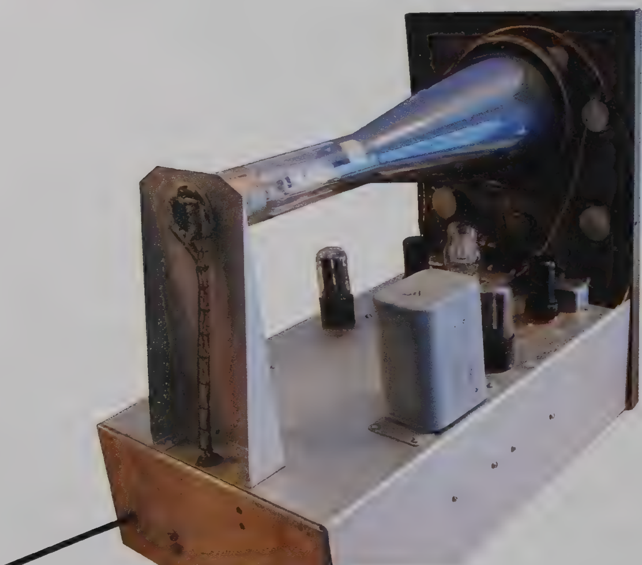


Fig. 4. Open View of O-1 Interior Showing Oil Filled Capacitor, 5BP1 CRT, Metal Tubes (War Surplus), Glass Tubes, Interior of Panel, and Very Nice Wiring by Original Builder.

Fig. 6. Unique Binding Posts Used Only on the First Oscilloscope—The O-1.

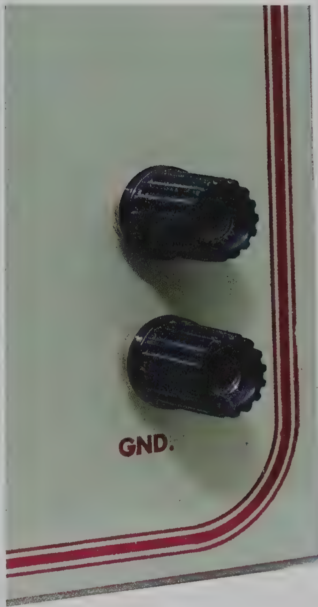


Fig. 8. Heathkit Universal Binding Post Used on the O-8 through O-12 Oscilloscopes and Later, as Well as Numerous Other Heathkits.

Fig. 7. Standard Binding Posts Used on the O-2 through O-7 Oscilloscopes.

O-2 OSCILLOSCOPE

The Heath Dec.-Jan. *Flyer* covering December 1947 to January 1948 announced the 1948 5-inch oscilloscope. This was the Model O-2. It was not indicated as such in the *Flyer*, although the designation Model O-2 is shown in the panel below the CRT (Fig. 2). The *Flyer* mentions the new size of the O-2 at 8½" x 13" x 17", lighter, smaller, and more compact (than the O-1). It had an improved sweep circuit, linear amplifiers, and a 5 position S-1 Sweep Frequency Switch. The first advertisement for the O-2 is shown in

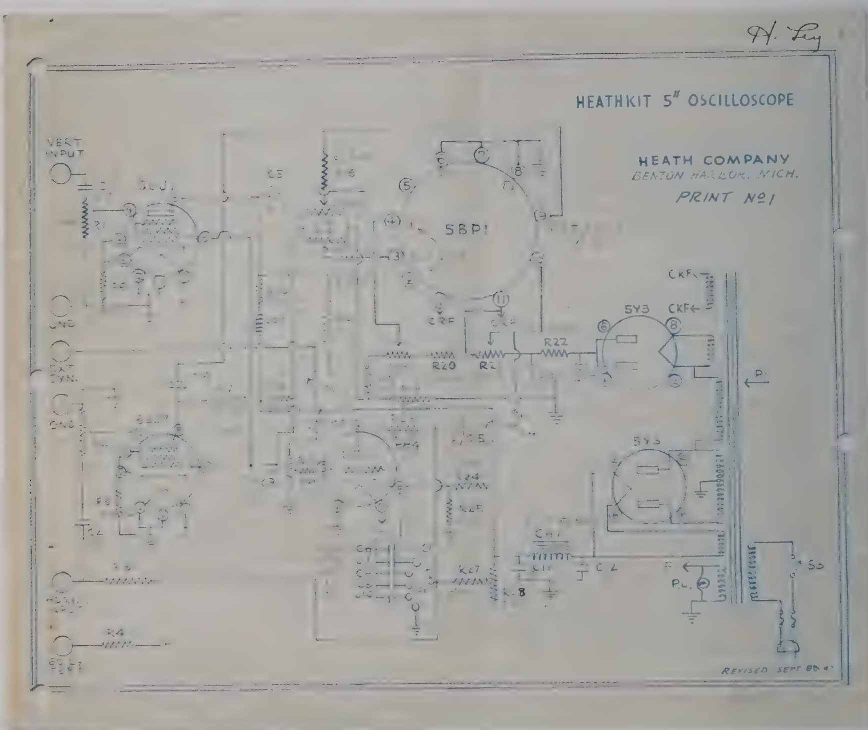


Fig. 9. O-1 Schematic Print No. 1 Revised September 8, 1947.

the February 1948 *Radio News* (9). The last advertisement was June 1948. The Schematics Print No. 1 (Fig. 10) is titled, "Heathkit Model O-2 Oscilloscope" and is dated January 8, 1948. The pictorial is Print No. 2 dated January 8, 1948. The O-2 construction sheet is dated January 12, 1948, and the O-2 Parts List sheet is dated January 27, 1948. A 1948 *Flyer* "Heathkit Test Equipment" shows an O-2 oscilloscope. It has a painted handle, toggle switches, and is not an O-1, therefore it is an O-2. Also, the *Flyer* notes "Heathkit Model O-2 Oscilloscope" on the Schematic Print No. 1 January 8, 1948. Significant changes from the O-1 were the addition of more standard binding posts (Fig. 7), all of which were on the lower part of the panel, not four on the sides as in the O-1, and simplified assembly and wiring (9). It was the last oscilloscope to have the painted brass carrying handle. Its shipping weight was 26 pounds.

The *Flyer* included the following, "Note: Price subject to change without notice, we cannot maintain this price when surplus cathode ray tubes are gone." The price of $39.50 was maintained until the Model O-7 in 1952 for $43.50. Figure 11 shows the underside of the O-2 chassis with the much smaller power transformer, and Figure 12 shows the upper interior.

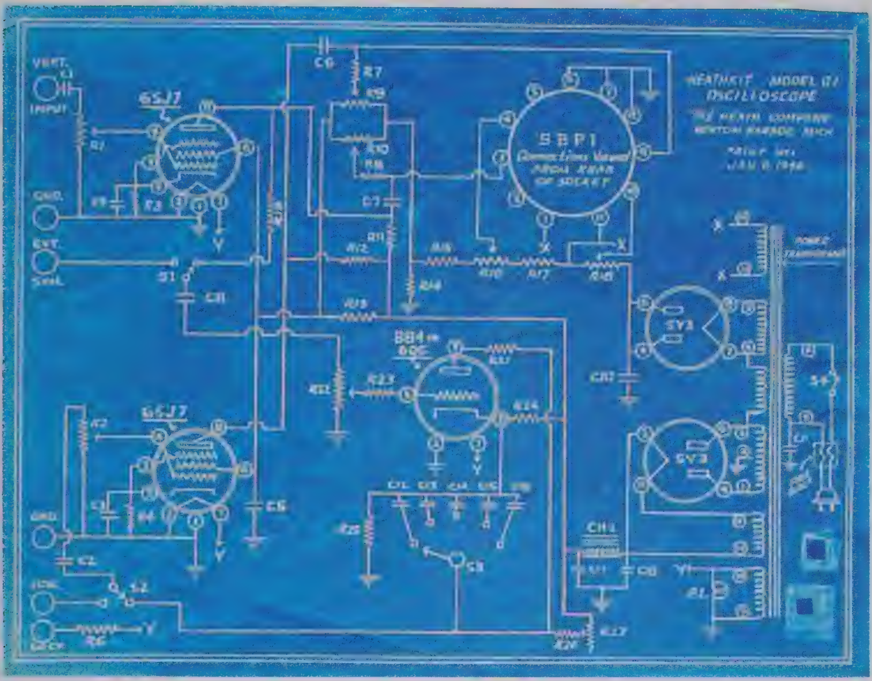


Fig. 10. O-2 Schematic Print No. 1 January 8, 1948.

O-3 OSCILLOSCOPE

The O-3 oscilloscope was advertised from July 1948 to September 1949. It was available in two types: Type 1 with toggle switches (Fig. 13) and Type 2 with less expensive slide switches (Fig. 14). *Radio and Television News*, January 1949, page 76 shows the O-3 Type 1 (toggle switches) with schematic, and *Radio and Television News*, April 1949, page 64 shows O-3 Type 2 (slide switches) with no schematic. Complicating an understanding of their sales history is that Heath often used earlier models in their advertising literature. The O-3 Type 1 with toggle switches was used in advertisements from *Radio News* from April 1948 through March 1949, but the author's instruction book for the O-3 Type 2 contains a parts list dated September 20, 1948 showing slide switches. The first *Radio News* advertisement showing slide switches was on page 64 of the April 1949 issue of *Radio and Television News*. Thus we can conclude the O-3 Type 1, with toggle switches, was sold from July 1948 through August 1948 (2 months), and the O-3 Type 2, with slide switches, was sold from September 1948 through September 1949 inclusive (13 months). This accounts for the relative rarity of O-3 oscilloscopes with toggle switches (the Type 1).

The O-3 is the first oscilloscope with a polished aluminum handle. Like the

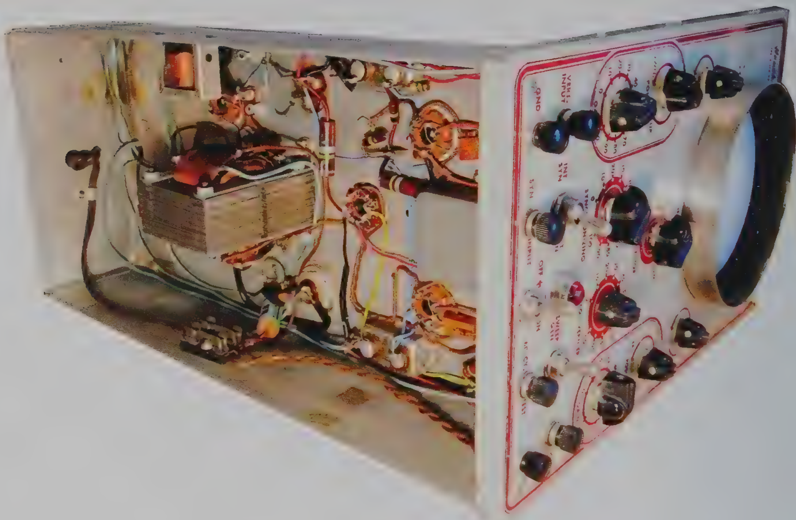


Fig. 11. Underside of O-2 Chassis Showing Smaller Transformer.

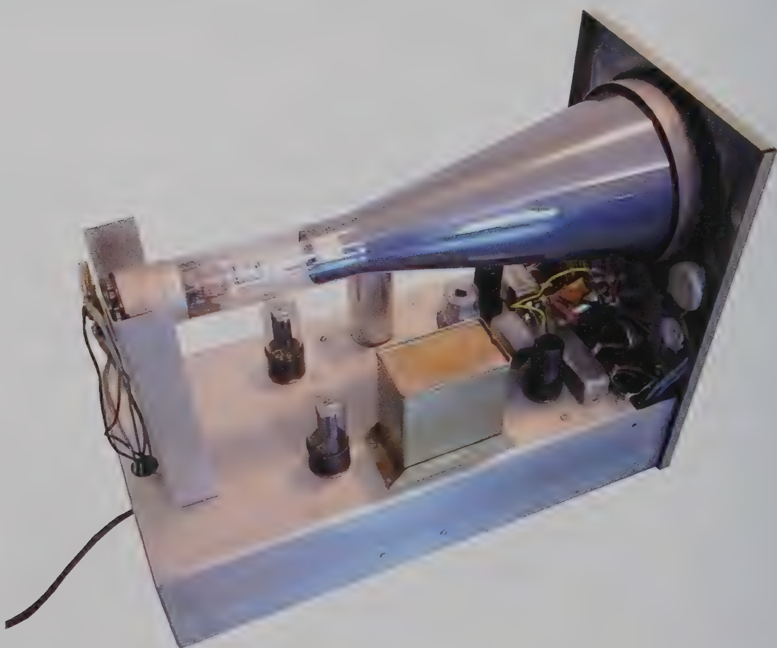


Fig. 12. Interior of O-2 Oscilloscope.

Fig. 13. O-3 Oscilloscope Type 1 with Toggle Switches.

Fig. 14. O-3 Oscilloscope Type 2 with Slide Switches.

O-2, it is lighter (24 pounds). It is also the first Heathkit oscilloscope to have an instruction manual rather than a series of separate sheets: schematic, instruction sheet, construction sheet, isometric drawing, and parts list. The manual (Fig. 15), places all of these in a single document having a green cover with a pasted-on label. Interestingly, the last pages of the manual have a bound-in section showing kits available and showed the O-2 oscilloscope and its Schematic Print No. 1 dated January 8, 1948. Yet to come are the Heathkit step-by-step construction manuals. These were first used for oscilloscopes from the O-5.

Major changes on the front panel of the O-3 were a switch on the horizontal and vertical amplifiers allowing direct connection to the CRT deflection plates. The tube complement was the same as the O-1 and O-2. An intensity modulation input was also provided at the rear of the oscilloscope.

O-4 OSCILLOSCOPE

The O-4 oscilloscope was advertised in *Radio and Television News* from April 1949 to August 1949 (5 months). A photograph of the O-4 oscilloscope is shown in Figure 16. It is similar to the O-3 except it has an external synchronization input terminal on the front panel. Oil filled capacitors were replaced by less expensive (or now more readily available) electrolytic capacitors. The CRT used was Type 5BP1 or 5BP4. The undated *Flyer* insert in the O-4 manual shows the O-3 with schematic dated April 3, 1948.

Fig. 16. O-4 Oscilloscope.

O-5 OSCILLOSCOPE

The O-5 oscilloscope was first advertised in the September 1949 *Radio and Television News* on page 74 and last advertised in *Radio and Television News* in August 1950 (12 months). The January 1950 *Radio and Television News*, page 73, advertisement includes a schematic for the O-5. The O-5 was promoted as the "new oscilloscope for 1950." It had many new features: push-pull horizontal and vertical amplifiers, a multivibrator sweep generator covering the range 15 Hz to 70,000 Hz, a magnetic alloy CRT shield, and improved sensitivity. Shipping weight was 30 pounds, and the price was still $39.50. It had seven tubes plus a 5BP1, 5BP4 or 5GP1 CRT according to the parts list. The O-5 schematic was dated January 2, 1950. The below chassis pictorial was dated July 31, 1949. The internal panel pictorial was dated January 2, 1950, and a second pictorial below

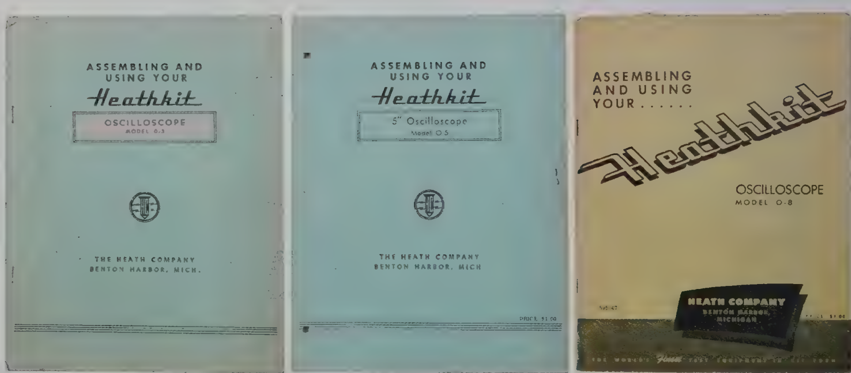


Fig. 15. First Oscilloscope Manual Was the O-3 with a Pasted-On White Title Label and Green Cover. This Replaced the Separate Schematic, Instruction Sheets, Pictorial, and Parts List Used in the O-1 and O-2 Oscilloscopes. The Second Manual Type Had a Printed Title Starting with the O-5. The Third Was a New Design Yellow Cover Manual Starting with the O-8.

the chassis was dated January 31, 1950. For the first time, the O-5 oscilloscope came with a calibrated CRT screen that could be snapped onto the CRT face. A kit was available, list No. 315 for $12.50, to convert the O-3 or O-4 oscilloscopes to push-pull amplifiers but not increase the sweep frequency range. The O-5 was the first Heathkit oscilloscope to provide "step by step assembly instructions" in their manual, pages 3-6. The manual also had a printed title for the first time, unlike the O-3 and O-4 that had a pasted-on label title (Fig. 15). The manual had no *Flyer* insert, unlike the O-3 and O-4.

O-6 OSCILLOSCOPE

The Heathkit O-6 was advertised as the 5-inch oscilloscope for 1951. Only one model of the Heathkit oscilloscope was still sold at any one time. The price was still $39.50. The O-6 was shown in the September 1950 *Flyer* and in *Radio and Television News* from September 1950 (on page 58) through August 1951 (12 months). The CRT shield was an improved type made by Allegheny Ludlum, the sweep frequency range had been increased, now covering 15 Hz to 100,000 Hz, it had positive or negative sync, and AC or DC push-pull amplifiers.

The September 1950 *Flyer* shows an O-5 with oval red lines around the two controls on the left and right sides. However, a small insert on the *Flyer* shows a view without these lines, which are a characteristic of the O-6. This is an example of Heath marketing showing the previous model in the latest advertising, i.e., not keeping up with the appearance of the new product. This happened in other Heathkits as well, making it important to use more than one source when identifying new products. The September 1950 *Radio and Television News* shows the O-5 but discusses the O-6 on page 58. No advertisement or *Flyers* showed schematics for 1951, nor was there a 1951 Heath catalog.

The O-6 had 10 tubes, and the shipping weight was 30 pounds. The O-6 instruction manual was the first Heathkit oscilloscope to use check off boxes in the step-by-step assembly instructions, on pages 2-10—a practice that became characteristic of Heathkit manuals. The O-6 oscilloscope instruction manual was also the first to include large fold-out drawings to assist with assembly.

O-7 OSCILLOSCOPE

The O-7 was advertised as the "Oscilloscope for 1952" in *Radio and Television News*, September 1951 through August 1952 (12 months). The price, for the first time, was increased to $43.50. It had 10 tubes, and the shipping weight was 29 pounds. It was also shown in the 1952 Heathkit Catalog on page 3. The CRT was supplied as a 5BP1, a 5BP4 or a 5GP1. The catalog included an O-7 schematic. The O-7 was the last "red-face" model to have a red stripe around the edge of the panel. The model number was moved from below the CRT on the panel to above the pilot light. A spot shape adjustment was provided on the panel.

O-8 OSCILLOSCOPE

The O-8 was the "Oscilloscope for 1953" and was advertised on page 4 in the 1953 Heathkit Catalog as well as in *Radio and Television News*, September 1952 through August 1953 (12 months). It had nine tubes plus a new high intensity CRT, the 5CP1. The catalog included an O-8 schematic. To further increase the intensity (brightness) available, Heath sold a 2200 volt kit (suitable for the O-8 only) for $7.50. Shipping weight was given at 24 pounds. A significant change in product design was the use of the new Heathkit universal binding posts (Fig. 8). This was the first oscilloscope to use the new yellow cover Heathkit manual (Fig. 15).

O-9 OSCILLOSCOPE

The price of the 5 inch oscilloscope increased to $59.50 in the 1954 Heathkit Catalog. The O-9 was advertised in *Radio and Television News*, September 1953 through August 1954 (12 months). It had 10 tubes plus the new 5UP1 CRT (not war surplus per page 4 of the 1954 Catalog). The 1954 Catalog on page 4 stated "over 60,000 oscilloscopes sold to date." The O-9 is the last "red-face" model. It had a shipping weight of 28 pounds. The catalog included an O-9 schematic. The sweep frequency range was less than claimed for the earlier O-6 model, being 10 Hz to 50,000 Hz. However, it had improved voltage regulation, a 1 volt peak-to-peak voltage calibration on the front panel, re-designed Heathkit knobs, and a color coded wiring harness.

O-10 OSCILLOSCOPE

The O-10 is shown in the 1955 Heathkit Catalog on page 6, in the 1956 Catalog on page 4, and was advertised in *Radio and Television News*, September 1954 through August 1956 (24 months). The price increased to $69.50. The O-10 was the first "O" series to use a charcoal grey panel and a two year product cycle. It had 10 tubes plus a 5UP1 CRT, and had a new sweep circuit which provided a substantial increase in range from 20 Hz to 500,000 Hz, two printed circuit boards, a shipping weight of 24 pounds, a net weight of 20½ pounds and feather grey knobs. The catalog included an O-10 schematic.

Other Heathkit oscilloscopes appeared for the first time. The 1955 Catalog showed the OM-1 5-inch oscilloscope using a 5BP1 CRT at $39.50 on page 8 and the OL-1 3-inch CRT at $29.50 on page 9. In the 1956 Catalog, the OM-1's price was increased to $49.50, as shown on page 6, and the OL-1 3-inch was still priced at $29.50.

O-11 OSCILLOSCOPE

The O-11 is listed in the 1957 Heathkit Catalog on page 6, in the 1958 Catalog on page 18, and in the 1956 Fall *Flyer*. It was first advertised in *Radio and Television News* in September 1956. Its appearance is similar to the O-10. The shipping weight was 22 pounds, and the net weight was 20½ pounds. It had 10 tubes plus a 5UP1 CRT. The price was $69.50 for 1957 and 1958. The 1957 and 1958 Catalogs included schematics. The 1957 Catalog lists an OM-2 on page 5 at $42.50. The OL-1 was dropped from

the 1957 Catalog and thereafter. The 1958 Catalog lists the OM-2 on page 19, still at $42.50.

O-12 OSCILLOSCOPE

This is the last of the Heathkit O" series oscilloscopes (Fig. 17). It is listed in the 1959 Heathkit Catalog on page 21 at $65.95, a slight price decrease from the O-11 at $69.50. The O-12 had an 11 tube circuit using a 5UP1 CRT. The catalog includes an O-12 schematic. The O-12 is the only model in the "O" series with a plastic handle and a green plastic pilot light cap. Mentioned on page 20 of the 1959 Catalog is a 5-inch "Professional" DC Oscilloscope, model OP-1, for $179.95. Also shown on page 22 was a new OM-3 General Purpose oscilloscope at $39.95, with seven tubes using a 5BP1 CRT. The O-12 was replaced in the Fall and Winter 1960-1961 Catalog on page 80 by the IO-30 at $76.95, this model being the first Heathkit oscilloscope with an off-center CRT, positioned to the left of the panel in the frontal view. The only mention of the O-12 in the Fall and Winter 1960-1961 Catalog was the statement on page 8 that the IO-30 is "Successor to the famed O-12."

The O-12 was the last in the fine series of oscilloscopes that historically owe their beginnings to the O-1. The O-1 started it all as well as being the very first Heath electronic kit.

Fig. 17. O-12 Oscilloscope, 1959. Note New Plastic Handle and Green Plastic Pilot Light Cap. This Is the Last of the "O" Heathkit Series That Started with the O-1.

CONCLUSION

After the major reduction in dimensions from 10" x 15" x 17¼" and the 55 pound weight from the O-1 to the O-2 and thereafter, with small variations, the weight stabilized at about 24 pounds and the dimensions to about 8½" x 13" x 17 ½" (Fig. 2). The changes were due to the adoption of smaller, more efficient, power transformers and the size reduction was due to a more compact design that was carried through the entire model series: the O-2 in 1948 through the O-12 in 1959 (about 12 years). It is interesting to note that Heathkit continued producing electronic kits until 1992, i.e. over 33 more years.

The O-2 through O-12 model series have a similar look, but with panel changes and internal circuit changes to improve performance. The O-1 through the O-9 have what collectors call the "red-face" panel of grey and maroon with certain panel details being simplified until the O-10 which was the first (in 1955) to have a charcoal grey panel with feather grey knobs. The charcoal grey color continued through the final oscilloscope in the series, the O-12 in 1959, that featured continuous improvement and higher quality. Thus ended this wonderful series of Heathkit oscilloscopes.

REFERENCES

1. The Earliest Heathkits and a Database for 1947-1956, Erich E. Brueschke, *AWA Review*, p. 81-113, Volume 23, 2010.
2. Chuck Penson, *Heathkits – A Guide to Amateur Radio Products*, 2nd Ed, CQ Communications, Inc., Hicksville, New York, 2003.
3. "From the Director", Tom Peterson, Jr., Director, *AWA Journal*, October 2010, p. 4.
4. First Heath Oscilloscope Kit Ad Under "Heath Electronic Surplus Bargains" Complete 5" Oscilloscope Kit $39.50. *Radio News*, July 1947, p. 122.
5. "The Best in Surplus", Ad Showing the First Picture of the Heathkit 5-inch Oscilloscope, $39.50, by the Heath Company of Benton Harbor, Michigan, *Radio News*, September 1947, p. 89.
6. First Picture of the First Heathkit 5" Oscilloscope Showing all the Parts in the "Complete Kit", *Radio News*, November 1947, p. 102.
7. Possible Lowest Price for a 5BP1 Cathode Ray Tube (World War II Surplus), Lafayette Radio, *Radio News*, August 1948, p. 114.
8. Last Ad for the First Heathkit Oscilloscope (The O-1), *Radio News*, January 1948, p. 79.
9. "Build Your Own Quality Test Equipment" Ad Showing the "New 1948 5-inch Oscilloscope (The O-2)", $39.50, *Radio News*, February 1948, p. 61.

PHOTO CREDITS

All items shown in the Figures, including the Heathkit O-1 oscilloscope, are in the collection of the author. All photos were done by Susan E. Golebiowski.

ACKNOWLEDGEMENTS

I want to thank Patricia F. Brueschke for assembling the manuscript, Susan E. Golebiowski for her photographic expertise and assistance, and my wife Frances for her endless patience and support of my collecting interests. With special thanks to Jay Whipple, Jr. and William Ross. Without the help and encouragement of these five individuals, this article would be wishful thinking.

ABOUT THE AUTHOR

Erich E. Brueschke BSEE, M.D., FAAFP, KC9ACE currently holds the Extra Class amateur radio license. He

held the call WøBPS from 1948 when he was in high school. Born on a ranch in rural South Dakota, U.S.A., radio was an important window to the world for him. He has a B.S. in Electrical Engineering from the South Dakota School of Mines and Technology. He worked for the Hughes Research and Development Laboratories in Culver City, California for five years, specializing in magnetics and in the effects of high vacuum on components. His last Hughes effort was on the Surveyor spacecraft in 1961-1962, which landed on the moon in 1966. He left Hughes to go to medical school at Temple University School of Medicine in Philadelphia, Pennsylvania. After training, he became a Captain in the U.S Air Force at the Aerospace Medical Research Laboratories at Wright-Patterson Air Force Base in Dayton, Ohio. He subsequently practiced family medicine in California and then joined the IIT Research Institute in Chicago, Illinois, where, as Director of Medical Engineering Research, he worked on artificial internal organs, including powering the artificial heart, for seven years. He then joined Rush Medical College in Chicago where he was the Chairman of Family Medicine and Professor of Physiology and Molecular Biophysics. He subsequently became Dean of Rush Medical College. He retired as Dean in 2000. He is currently the Distinguished Professor of Medicine at Rush Medical College at Rush University in Chicago. He holds two patents, has published numerous papers in the engineering, medical and scientific literature, and is a member of numerous professional societies. He has previously published in the AWA Review in 2010 and 2012. His major collecting interests are early scientific educational apparatus, crystal sets, early battery radios, and Heathkits. He has collected, preserved and restored radios and scientific devices for over 29 years. He has been a member of the AWA for 22 years and is a member of the Radio Club of America. He invites correspondence and comments at eeb44@hotmail.com.

Erich Brueschke

The Titanic's Impact on Wireless & Radio

From Disaster To Triumph

Abstract

The year 2012 marked the centennial of the Titanic disaster. The 2012 AWA Review included several articles documenting our members' research about the Titanic, Marconi wireless and maritime radio. The 2012 AWA Conference featured a special display of Titanic and Marconi artifacts and a Titanic film festival. The following article is the Keynote Address given at the 2012 AWA Conference on behalf of the AWA and the Radio Club of America by David Bart. It concluded the AWA's centennial commemoration of this important event in radio history.

What Is It About The Titanic?

In a century that witnessed two world wars, United Nations conflicts, countless natural disasters and a new world political order, why are we still so fascinated with the *Titanic*? The story incorporates all the themes of a perfect Greek tragedy; including hubris, achievement, magnificence and downfall. The events fit neatly into a 2-hour drama capable of holding our attention on film, on television or in a radio drama. The story is filled with intrigue, and offers unlimited detail and unresolved questions to explore.

The sinking of the Titanic symbolizes the end of a Victorian era of opulence and prestige. Indeed, we are still shocked at the loss of nine millionaires and thousands of people in one event. It represents the beginning of consumer legal protections, including issues of fairness among the 1st, 2nd and 3rd class passengers; and for those willing to read the dramatic transcripts, three primary court hearings which have left significant legal precedent. At its best, it is a good ghost story compelling us to wonder what secrets may still be hidden in the wreck. Its legacy marks the birth of a new form of communication.

Our fascination continues with the centennial commemoration. Online searches for the "*Titanic* Disaster" and "*Titanic* Commemoration" reveal that radio collectors and historians are not alone in their fascination with the events of April 15, 1912. Searches

Fig. 1. *Titanic* Poster, 1912. (*timesunion.com and New York Times*)

performed in late July 2012 revealed 372 hits on Amazon Books. In just the past year, 30,900 blog postings and 1,100 discussions were tracking in Google. Even more stunning are the 589,000 website hits. The IMDb database includes 15 feature films and television movies.

Titanic Radio Commemorations

Titanic's importance to radio is well known and was widely celebrated on the centennial. As shown in Table 2, at least 15 commemorative radio events occurred the week of April 15, 2012. The events included the Chatham Marconi Maritime Center in Massachusetts at Wellfleet, the former Marconi station. Station EI100T beckoned from Cobh/Queenstown, Ireland which was *Titanic's* last port of call. Other stations operated from the Connemara Marconi Station, Belfast City Hall, and the Southampton Docks. Station GR100MGY operated from multiple locations using *Titanic's* original call sign. VO1MCE hailed from Cape Race, and GB100MPA was operated by the Radio Officers Association Radio Society using *Carpathia's* call sign. GB100MPA was located at the Lizard Marconi Wireless Station and Museum in Cornwall, England. Station VE0MGY operated onboard a maritime station at the *Titanic* sinking area. (Selman, 2012) Together, these and other stations commemorated one of the most notable radio events in history.

TABLE 1. INTERNET SEARCHES ON TITANIC DISASTER - JULY 2012

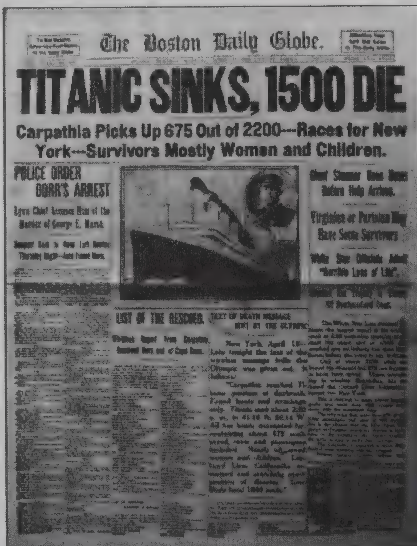
Amazon Books	372 Hits
Amazon Movies	14 Hits
Google Blog Postings Jan. 1-June 19, 2012	29,200
Google Discussions	895
Google Website Hits	303,200
Google "Titanic Commemoration"	22,300
IMDb Online Movie Database ("HMS Titanic/Titanic Disaster")	15 Feature/TV Movies

TABLE 2. SELECTED TITANIC CENTENNIAL RADIO STATIONS OPERATING IN APRIL 2012[1]	
Station	***Description***
KM1CC & WA1WCC	Chatham Marconi Maritime Center in Massachusetts April 12-15 and also a mobile ham radio operation at Wellfleet, the former historic Marconi site
EI100T	Cobh (Queenstown) *Titanic's* last port of call
EI1MGY	Lahardane was home to many people who perished on *Titanic*
EI4CDN	Connemara Marconi Station - Jack Phillips was stationed here
GI100MGY	Belfast City Hall - home to Harland and Wolff shipyards
GB100WSL	Southampton Docks near *Titanic's* departure point (WSL=White Star Line)
GR100MGY	Multiple locations using the *Titanic's* call sign
GB100GGM	Old Mill, Gwent UK - the only confirmed land based reception of *Titanic's* distress calls
GB0TI	Lichfield Group commemorated Capt E J Smith
GB100C	Commemorated the *Carpathia*
GB100MPA	The Radio Officers Association operated Lizard Wireless Station in Cornwall commemorating *Carpathia's* call sign
GB100MWT	Multiple locations including Chelmsford and later from BAe Systems celebrated Marconi Wireless Telegraph Co.
GX0MWT	Chelmsford for Radio Maritime Day
VE0MGY	Shipboard maritime station at the *Titanic* sinking area
VO1MGY	Admiralty House Communications Museum in Mount Pearl NL Canada
VO1MCE	Cape Race

Wireless and the Titanic

The *Titanic* disaster had a monumental impact on the public's awareness of radio. It was preceded in 1909 by Jack Binns and the highly publicized rescue of passengers onboard the *Republic*. By 1912, the public's knowledge of wireless and its potential to save lives was already taking hold by 1912. Newspapers heralded the latest *Titanic* news received by "wireless". Press releases quoted the current messages and kept the public informed of the latest developments as *Titanic* sank, and the *Carpathia* rescued survivors and later arrived in New York. This was, in the context of its times, an event that unfolded in "real time".

Titanic transmitted both CQD and SOS distress signals. The 1906 Berlin International Radiotelegraphic Conference had already attempted to standardize call letters for ships in distress. British Marconi operators used CQD. The Germans started with SOE and adopted SOS in April 1905. The conference ultimately settled on the more efficient SOS. Yet, even though


The Boston Daily Globe.

TITANIC SINKS, 1500 DIE

Carpathia Picks Up 675 Out of 2200---Races for New York---Survivors Mostly Women and Children.

POLICE ORDER DORR'S ARREST

LIST OF THE RESCUED.

Fig. 2. A Representative Newspaper Headline From The *Titanic* Disaster. (Authors' Collection)

Great Britain had adopted the Berlin conference's proposals by 1908, British Marconi wireless operators largely ignored them.[1]

Since February 1904, the Marconi Wireless Company required its operators to use CQD for distress signals. However, CQD was never adopted as an international standard since it could be mistaken for a general call CQ if reception was poor.[2] Marconi Operator Jack Binns sent the most famous CQD on January 23, 1909, leading to the rescue of passengers and crew from *RMS Republic*.[3] Jack Phillips and Harold Bride later interspersed both CQD and SOS during the *Titanic*'s calls for help.[4]

By 1912, the use of SOS was not new and many SOS rescues had already taken place prior to *Titanic*. Both the U.S. Navy and Royal Canadian Navy were using SOS. As shown in Table 2, between 1909 and 1911, six major rescues using SOS had received significant newspaper coverage. The Coastal Liner *Ontario* used SOS on April 9, 1912 when fire broke out in the hold en route from Baltimore to Boston in heavy seas. The crew safely beached the vessel on the Long Island coast near Montauk. *Ontario's* passengers were never in any real danger, because numerous tugs and cutters summoned by SOS were standing by. This rescue occurred only days before the sinking of the *Titanic*.

The story of the wireless operators involved with the *Titanic* has become legend. It has been the subject of numerous books and articles and yet, the surprising youth of the operators

Fig. 3. Marconi Wireless Operator Jack Binns After His Rescue From *The Republic*. (www.rms-republic.com)

Fig. 4. United Wireless Operator Herbert O. Benson on the *SS Merida*. (*Library of Congress, Digital ID: ggbain.09195*).

TABLE 3. EARLY USES OF SOS PRIOR TO TITANIC[6]		
June 10, 1909	*Cunard Steamer Slavonia*	*Slavonia* was wrecked off the Azores and two steamers responded to her SOS (First Use of SOS)
Aug. 11, 1909	*Steamship Arapahoe*	Broke a shaft and began drifting off the North Carolina coast summoning help via SOS
Feb. 4, 1910	*Steamer Kentucky*	Ran into heavy weather off the Virginia Capes and took on water faster than the pumps could control. *Alamo* responded and took off *Kentucky's* passengers and crew before it sank
May 13, 1911	*Liner Merida*	Collided with steamship *Admiral Farragut* in fog off Cape Charles, Virginia, and sank. Passengers and crew in lifeboats were picked up by *Hamilton*, which arrived in response to *Merida's* SOS transmission
July 30, 1911	*Canadian Navy Cruiser Niobe*	Ran ashore in heavy fog and gale while rounding Nova Scotia's Cape Sable on her way back to Halifax and transmitted SOS distress calls
Dec. 3, 1911	*U.S. Navy Collier Sterling*	Collided with the coal steamer *Dorothy* off the coast of Virginia. *Sterling* summoned aid with an SOS but managed to safely run aground just west of Cape Henry
April 9, 1912	*Coastal Liner Ontario*	Fire broke out in the hold en route from Baltimore to Boston in heavy seas. The crew safely beached the vessel on the Long Island coast near Montauk. *Ontario's* passengers were never in any real danger, because numerous tugs and cutters summoned by SOS were standing by

is often overlooked. Indeed, they were very young. Harold Thomas Cottam onboard the *Carpathia* was 21 years old; Jack Phillips on the *Titanic* was 25 years old and was a mentor to Cottam. Harold Bride onboard the *Titanic* was also 21 years old. Despite their youth, they referred to each other as OM "Old Man" in the familiar wireless jargon of the day. At one point, Phillips jokingly told Bride to use the new SOS in addition to CQD since this might be the only time Bride would use the new signal. Phillips, unfortunately, would not survive the icy waters of the North Atlantic that night.[5]

The Titanic Inquiry[6]

Inquiries into the disaster were conducted on both sides of the Atlantic. The American inquiry was conducted by the U.S. Senate led by the renowned trust-busting legislator, Senator William Alden Smith. The senate inquiry

Fig. 5. Wireless Operators (Left to Right): Harold Thomas Cottam, Jack Phillips, Harold Bride. *(Titanic Heroes Website)*

focused on "how" the disaster happened. It lasted 17 days from April 19 to May 25, 1912 and called 82 witnesses. Jurisdictional issues over the right to subpoena foreign citizens, most of whom were British, kept certain aspects of the inquiry informal. Three Republicans and three Democrats formed the panel. Under Senator Smith's leadership, the inquiry was primarily consumer safety oriented. It found widespread negligence and condemned the lax regulatory enforcement of the British Board of Trade's oversight of the Atlantic shipping industry. It criticized onboard procedures, wireless procedures, safety procedures and many other items that contributed to the loss of life. At the time, Senator Smith was criticized for his lack of nautical knowledge, but he was a skilled trial attorney who knew how to gather evidence. The report of the inquiry and Senator Smith's subsequent speech in the U.S. Senate were widely heralded for revealing facts and issues that could not be ignored. (Lord, 1998)

The British inquiry was conducted by the Wreck Commission of the British Board of Trade under Lord Mersey. The British inquiry focused on "why" the disaster happened. It lasted 36 days from May 2 to July 3, 1912 and called 102 witnesses. It emphasized nautical engineering and accepted practices at sea. This inquiry found that the British Board of Trade and White Star Line acted reasonably given the accepted practices of the day. The Wreck Commission issued a very lengthy report filled with nautical engineering details.

Fig. 6. Senator William Alden Smith (R - Michigan) (*Library of Congress, Digital ID: hec 15855*)

It did not find negligence, and at the time was considered a whitewash. Lord Mersey would later oversee the Lusitania inquiry that was also criticized. (Lord, 1998)

Despite differences in focus and testimony, many of the conclusions and recommendations of both inquiries were similar. Both inquiries recommended dozens of new safety laws and safety improvements for ocean-going vessels. Radio came into particular focus; including the six messages warning Titanic of ice, the unheeded CQD/SOS distress messages and the confusion in subsequent radio traffic. Senator Smith targeted the unregulated wireless spectrum, Marconi's monopoly, the laissez-faire status of the wireless, and appealed for international regulation of radio. In subsequent interviews and articles, even Marconi favored 24 hour monitoring of distress frequencies by

Fig 7. John Charles Bigham "Lord Mersey". (*www.encyclopedia-titanica.org*)

at least two operators, and he encouraged limitations on amateur operators. (Marconi, 1912; Lord, 1998)

Titanic Changed Radio Forever[7]

The *Titanic* disaster led to the passage of the U.S. Radio Act of 1912. By 1909 public opinion was moving toward regulation. The Wireless Ship Act of 1910 brought the U.S. into partial compliance with the 1906 Berlin International Wireless Convention. It required that all U.S. ships traveling over 200 miles off the coast and carrying over 50 passengers be equipped with wireless radio equipment having a range of 100 miles by July 1911. It was amended on July 23, 1912 (three months after *Titanic*) to cover additional vessels. This amendment was a response to U.S. representatives being initially un-invited to the 1912 London International Radiotelegraphic Convention because the U.S. had not yet ratified or complied with the long-standing 1906 Berlin provisions.

President Taft signed the 1912 Act

Fig. 8. The Only Known Image Showing Both Marconi (L) and Harold Bride (R) at the U.S. Inquiry. (*The Press, Philadelphia, April 23, 1912; Authors' Collection*)

Fig. 9. Der Untergang der "*Titanic*", Color Illustration by Willy Stöwer for "*Die Gartenlaube*" Magazine, 1912. (*Wikimedia Commons Website*)

to Regulate Radio Communication on August 23, 1912. It went into effect on December 13. The Radio Act of 1912 further implemented provisions of the earlier 1906 Berlin Convention. It also incorporated the new London Convention, dated July 5, 1912, which had already gone effective on July 1, 1913.

Captain Howeth's 1963 *History of Communications-Electronics in the United States Navy* states:

"The Titanic disaster has often been given as the compelling reason behind the enactment of this legislation. This is not correct. The subcommittee of the Senate Commerce Committee had completed its masterful work of bringing the opposing views into proper focus and the bill had been reported out prior to the disaster. It did, however, awaken congressional eyes to its wisdom and necessity and insured its final enactment."

Titanic accomplished what the earlier sinking of the *Republic* had not, despite the publicity surrounding Jack Binns' heroic actions and the use of wireless at sea nearly three years earlier. In fact, twenty-eight bills to regulate radio had been introduced to Congress or failed to become law from 1902 to 1912. It was the Titanic that finally brought the issue to resolution. (Howeth, 1963)

Together, the Radio Act of 1912 and Amended Act of 1910 form the first comprehensive U.S. radio legislation.[8]

Ships with 50 or more passengers travelling more than 200 miles between ports were required to have wireless apparatus capable of operating 100 miles day or night. Any "person, company, or corporation" using a device for radio communication in the U.S. was required to have a license, issued by the Dept. of Commerce, subject to proficiency testing. Stations were required to use a designated wave length below 600 meters or above 1,600 meters. Amateurs were restricted below 200 meters with stiff penalties for "uttering or transmitting a false or fraudulent distress signal or call", a fine of $2,500 or up to five years in prison. The U.S. Navy was given unrestricted access to 600-1,600 meters and was required to build a string of land stations to communicate with both naval and commercial vessels. Absolute priority was given to signals and radiograms relating to ships in distress. (Navigation Laws, 1920) The Radio Act of 1912 and the U.S. Dept. of Commerce would oversee U.S. radio law until 1927 when the Federal Radio Commission (FRC) was established. The Federal Communications Commission later replaced the FRC in 1934.

London's Third International Radiotelegraph Convention in June 1912 reaffirmed the international priority for distress calls and mandated standards for oceangoing ships. Twenty-nine nations and eight dominions/colonies were represented at the convention. It established 600 meters/500 kHz as the primary frequency for sea-going communication. Continuous radio watch by certain ships was required. Compulsory "listening-in" periods were required for those ships that were not required to maintain constant watch. Vessels had to be fitted with auxiliary apparatus capable of working six hours. Silence was required during 3 minute "listening-in" periods at the ¼ and ¾ hour marks. Radio operators and apparatus were placed under the direct authority of the captain. All radio transmissions in the vicinity of a ship in distress were placed under the control of that ship. Priority transmission of weather and time signals were given to ships upon request. The Convention also recommended that certain classes of ships be required to carry a radio-telegraphic installation.[9]

Progress came quickly. By the end of 1912, there were 580 shipboard wireless installations worldwide. Wireless was also in use on the Great Lakes. In November, 1913 Great Lakes storms destroyed 19 vessels, none of which were equipped with wireless; all vessels with radio received warning of the coming storms and sought safety.[10]

Institute of Radio Engineers (IRE)

Prominent leaders in radio also responded to *Titanic*. From 1912-1913, the newly formed Institute of Radio Engineers (IRE) immediately focused its efforts on standards for maritime communications. The IRE was formed in May 1912, one month after *Titanic*, as a break-away organization from American Institute of Electrical Engineers (AIEE) to focus on wireless/radio communications. It resulted from the merger of the Society of Wireless

Telegraph Engineers (formed in 1907) and the Wireless Institute (formed in 1908). Jack Binns of the Republic, had already published a 1909 article in the Proceedings of the Wireless Institute entitled "How Business Can Best Be Handled In Case of Distress". (Proceedings of the IEEE, 2012, Feb.) The first issues of the new Proceedings of the IRE in 1913-14 published several articles about the standardization of equipment and efficiency in operating rules for maritime radio traffic.

IRE's founder and first President, Robert E. Marriott, led the IRE's debate on standards. Radio Operation by Steamship Companies by Robert Marriott in 1913 included transcribed discussion among Farnsworth, Quesne, Gage, Espenscheid, Israel, Fay, Goldsmith, Hogan and Marriott about the scope, range and content of recommended standards.[11] Specifications for Steamship Radio Equipment by Robert Marriott in 1914 included 64 recommended specifications and another transcribed discussion, this time among Hill, Stone, Parkhurst, Hogan, Goldsmith, Simon, and Marriott, about the scope, range and content of recommended standards.[12]

V. Ford Greaves, a new radio engineer from the U.S. Dept. of Commerce Bureau of Navigation, and a young David Sarnoff focused on training and traffic regulation. The Radio Operator Problem by V. Ford Greaves in 1914 focused on proficiency training, Continental Morse vs. American Morse, and standardized skills and testing methods employed by the Bureau of Navigation of the Department of Commerce.[13] Commercial operators were compared to the Naval Radio Service and other governmental departments, and the adoption of the Omnigraph as a testing tool was explained. Radio Traffic by David Sarnoff in 1914 focused on traffic regulation in the procurement and movement of message traffic; contracts for equipment and charges among the message conveying entities; and, economical and efficient operation by ships at sea.[14] He compared the procedures of American Marconi Company to those used by land line telegraph company organizations.

Fig. 10. Robert E. Marriott. (*IEEE Global History Network Website*)

Fig. 11. David Sarnoff in 1922. (*Wikimedia Commons Website*)

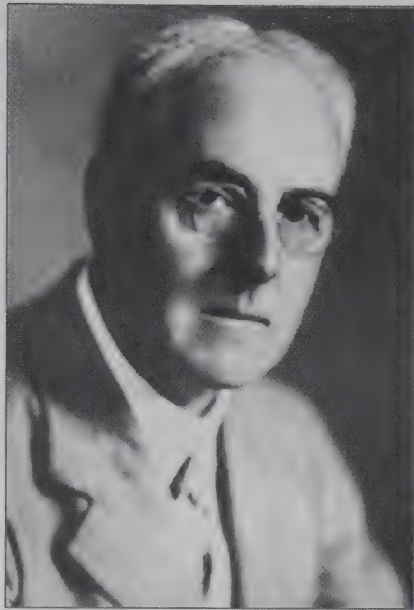


Fig. 12. Lewis Fry Richardson. (*U.S. National Oceanic and Atmospheric Administration*)

Titanic Expanded The Application of Radio

Efforts to develop undersea range finding and radio communications began immediately following *Titanic*. Just five days after *Titanic* sank, Lewis Fry Richardson made a provisional application for a British patent for an "Apparatus for warning ship of its approach to large objects in a fog". Three weeks later, he made a provisional application for a patent on an underwater version of his echo-ranging device which was issued March 6, 1913. Although the patent did not lead to a working model, his work anticipated the invention of sonar by Paul Langevin and Robert Boyle six years later.[15]

Reginald Fessenden also went to work on echo-location immediately following *Titanic*. Two months after *Titanic*, Fessenden began working on a high-frequency oscillator to measure the depth of water beneath a ship and to detect underwater hazards and icebergs. Fessenden and the Submarine Signal Company transmitted messages several miles underwater between tugboats in Boston Harbor, Massachusetts in January 1913. In 1914, the device was tested aboard the *U.S. Revenue Cutter Miami*. It could detect icebergs from a distance of up to four kilometers and map their underwater contours.[16]

The *Volturno* Disaster[17]

Eighteen months after *Titanic*, another ship would make headlines about the use of wireless in an at-sea disaster. In October 1913, the *SS Volturno* ocean liner burned and sank

Fig. 13. U.S. Revenue Cutter *Miami* by an Iceberg. (*Scientific American Supplement, No. 2071, Sept. 11, 1915. Image from NOAA Photo Library*)

not far from the *Titanic's* resting place. *Volturno*, with immigrants bound for New York, caught fire in a North Atlantic gale.

The crew attempted to fight the fire for two hours before the captain had his wireless operator send out SOS signals. Eleven ships heeded the distress calls, arriving throughout the day after navigating through dangerously high seas. Several lifeboats with women and children were launched which either capsized or were smashed by the hull of the heaving ship, killing all onboard.

Fig. 14. Image of the Volturno Rescue in *The Daily Mirror*, 1913. (*Flickr Website*)

Captain James Clayton Barr of *Carmania*, the first ship to arrive, took command of the rescue effort and began coordinating his efforts by wireless. He had the rescue vessels form a "battle line" slowly circling the burning ship, training their searchlights on the scene all night.

Poor weather, high seas, and fearful passengers hampered rescue efforts. Shortly before dawn, a large explosion rocked *Volturno*. The next morning the tanker *Narragansett* sprayed lubricating oil on the sea to help calm the surface. The oil and the lessening storm allowed the other ships to send more lifeboats to *Volturno*. In all, 521 passengers and crew were rescued by ten of the ships. The death toll was 136, mostly women and children from the early lifeboat launchings.

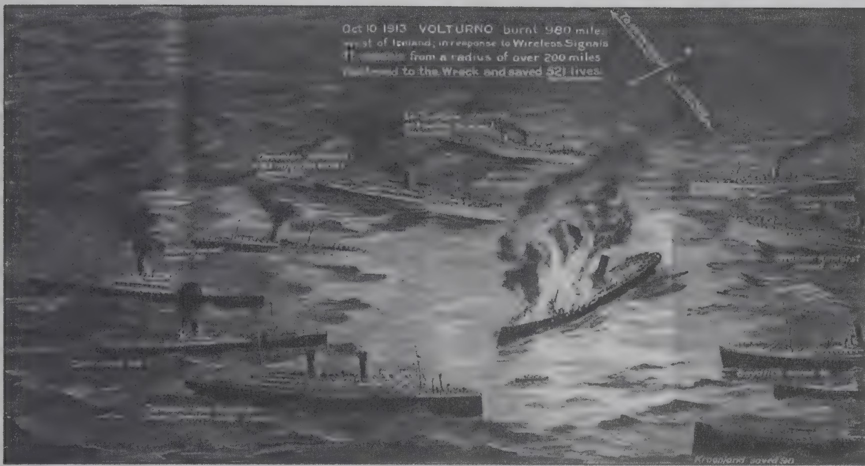


Fig. 15. Portion of Two Page Spread in The Graphic, Oct. 25, 1913. (*The Burning Of The Volturno Website*)

Volturno demonstrated the ability of wireless to coordinate ships at sea. The rescue was almost entirely directed by wireless with vessels arriving from 50-200 miles away. The *Philadelphia*

LINER VOLTURNO BURNS AT SEA, 136 LOST;
TEN SHIPS, CALLED BY WIRELESS, SAVE 52
STORM SWAMPS DOOMED SHIP'S LIFEBO

Rescuers Held
High Seas M
Thursday N

FLAMES SWEEP SH

Passengers Huddle
Till Help Reache
on Friday Mor

EXPLOSION START

Some Killed by
Others Die Where
Are Smashe

TRAGEDY IN STEAMS

S O S Signal Bring
Aid—Survivors Sa
in Rescue Fle

CAPTAIN AMONG TH

Lost Ship of Uranium
from Rotterdam to Ne

THE ILL-FATED VOLTURNO

CAPTAIN FRANCIS INCH

NORTH ATLANTIC

THE BURNING VOLTURNO WITH TEN SHIPS STANDING BY

Fig. 16. *New York Times*, Oct. 12, 1913. (*The Burning Of The Volturno Website*)

Record summarized the importance of wireless:

"*There was no confusion in the working of the wireless, no interference and breaking into the conversations between the calling vessel and those who answered, and every ship within hail responded with alacrity, so that at the time of the rescue there were ten steamers standing by.*"(*The Loss of the Volturno, 1913*)

Birth of the International Ice Patrol[18]

The *Titanic* disaster led directly to the establishment of the International Ice Patrol (IIP), the world's first international safety cooperative. The IIP was only able to operate effectively due to its use of wireless and later radio communication.

Starting in 1912, the U.S. took a leading role in efforts to warn about icebergs. After *Titanic*, the U.S. Navy Scout Cruisers Chester and Birmingham patrolled the Grand Banks. In 1913, the U.S. Revenue Cutter Service (later the U.S. Coast Guard) assumed responsibility, assigning the cutters *Seneca* and *Miami* to conduct patrols.

The International Conference on the Safety of Life at Sea convened on November 12, 1913, and its international maritime safety treaty was signed on January 30, 1914. The International Convention for the Safety of Life at Sea (SOLAS) called for an international derelict-destruction, ice observation and ice patrol service to be created for the North Atlantic under U.S. management. Since February 7, 1914, the

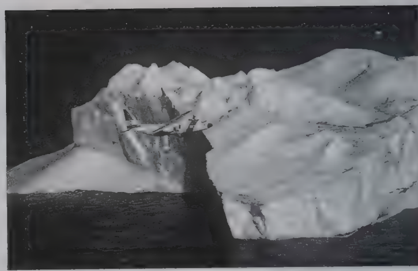


Fig. 17. International Ice Patrol in Operation. (*International Ice Patrol*)

U.S. Revenue Cutter Service/U.S. Coast Guard has maintained a patrol. Subsequent SOLAS conventions in 1929, 1948, 1960 and 1974 did not recommend any basic changes to IIP. (Young, 2012) Today, IIP is the longest running international military cooperative in history with seventeen nations contributing funding.

Today, just as in 1912, ships crossing the North Atlantic are required to radio their positions and all iceberg sightings to the U.S. Coast Guard which provides airborne mappings and issues a daily iceberg analysis on behalf of the IIP for use by all ships in the region. From 1980-2005, there were 57 incidents involving icebergs. Since 1913, not a single ship that heeded the warnings has struck an iceberg. (Safety and Shipping, 2012; Young, 2012)

IIP continues to recognize the legacy of the *Titanic* in its work. Each year, the U.S. Coast Guard places two wreaths at the *Titanic* site on behalf of both the *Titanic* Historical Society and the IIP to commemorate the lives lost and lessons learned in 1912. (International Ice Patrol Website, 2012)

Fig. 18. Placement of Wreaths At The *Titanic* Site For The *Titanic* Historical Society And For International Ice Patrol. (*International Ice Patrol*)

A Century of Maritime Safety

Since 1912, the major improvements in safety have continued to be dominated by applications of radio science. Half of all major improvements relate to radio and its applications. As shown in a timeline prepared by Seafarers International Research Centre (SIRC) And Allianz Global Corporate & Specialty (AGCS), the major radio related improvements include SOLAS, RADAR, LORAN, VHF and GPS as well as computer applications of communication technology.[19]

Today's ships are more than 5.5 times larger than *Titanic* in gross tonnage. The Seafarers International Research Centre (SIRC) and Allianz Global Corporate & Specialty (AGCS) reported that the *Titanic* weighed in at 46,328 tons and was 269 meters versus the *Queen Mary 2* at 150,000 tons and 345 meters. By comparison, the *Knock Nevis* super-tanker was 260,851 tons and 458 meters! (Safety and Shipping, 2012)

Over the years, the presence of icebergs on the North Atlantic has often been a significantly worse problem than the experience of 1912. Prior to 1970, the IIP reported only three years with more than 1,000 icebergs: 1912, 1929 and 1945. Since 1970, the ice patrol has reported more than 1,000 icebergs in 12 separate years. The worst year was in 1984 when the ice patrol identified approximately 2,200 icebergs. Activity remains highly varied, with very few icebergs spotted in 2010 and 2011. The five year running averages have, in fact, been declining since the mid-1990s. (Murphy, 2011)

Legacy of Success

Overall, today's shipping is estimated to be 85% safer than in 1912, despite having nearly 3.5 times as many ships afloat and 23.1 times the gross tons at sea. The *Lloyd's Register Fairplay, World Fleet Statistics* shows that total losses have dropped from 1% of the 1910 world fleet of 30,038 ships to 0.1% of the 2010 world fleet with 103,392 ships afloat. Incredibly, 49% of losses in recent years are due to foundering, and another 18% are due to wreck or stranding; collisions still account for 12% of all losses. (Safety and Shipping, 2012)

The leading cause of losses at sea today remains human error. But, although 75% of today's losses still result from human mistakes, there have been <u>no</u> losses due to iceberg collisions since the *Titanic*. (Safety and Shipping, 2012)

Advances in radio and communications

technology get the credit, together with continuing international cooperation toward a shared goal of saving lives. This is the true memorial to the heroes, the victims and the survivors of the *Titanic.*

So, why should we still think about *Titanic* today? Because, the *Titanic's* true legacy is the ongoing international cooperation and the international adoption of new goals and standards for communication for the benefit all mankind.

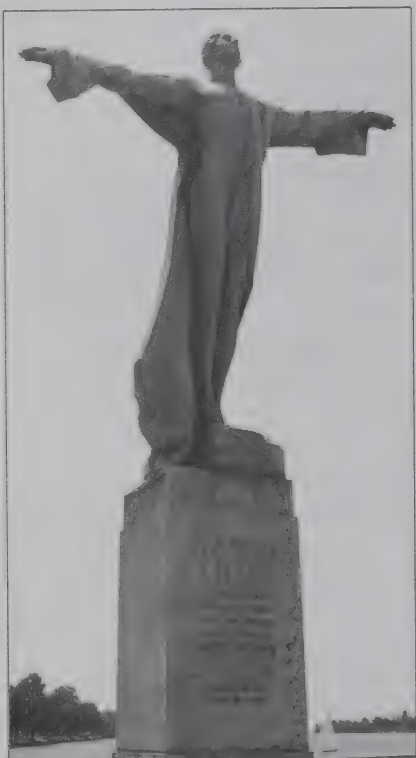


Fig. 19. *Titanic* Memorial, Washington DC. (Photograph by the Authors)

ACKNOWLEDGEMENTS

The authors express their gratitude to Jim and Felicia Kreuzer for their friendship and continuing support in providing numerous artifacts, exhibit preparations and documentation regarding Marconi, the *Titanic*, telegraph and early wireless history. The materials and information provided by the Kreuzers have been used in displays at the Antique Wireless Association, Radio Club of America, New York Historical Society and the Antique Radio Club of Illinois as well as articles published by the AWA, RCA and the Institute of Electrical and Electronics Engineers on these and related topics. Together, the authors and the Kreuzers compiled the *Titanic* Centennial Commemoration exhibits at the 2012 Antique Wireless Association Conference and at Radiofest 2012.

REFERENCES

Baarslag, Karl. (1935). *SOS to the Rescue.* New York: Oxford University Press, Inc. Note the British edition is titled *SOS: Radio Rescues at Sea.*

Booth, John and Coughlan, Sean. (1993). *Titanic: Signals of Disaster.* Westbury, Wiltshire, England:

White Star Publications.

Bride, Harold. (1912, April 28). Thrilling Tale By Titanic's Surviving Wireless Man. *New York Times.*

The Burning Of The Volturno An Extraordinary October 1913 Marine Tragedy Website. (2012) Including original documents and articles including *New York Times* October 12-24, 1913. See http://www.

searlecanada.org/volturno/volturno01.html.

Caddell, Alfred M. (1924, April). C.Q.D. *Radio Broadcast.*

Daamen, Jan. (2001). *The Volturno Ship Disaster - October 1913 Website*. See http://homepages.rootsweb.ancestry.com/~daamen1/volturno/.

Gavin, Alison and Zarr, Christopher. (2012, Spring). They Said It Couldn't Sink: NARA Records Detail Losses, Investigation of Titanic's Demise. *Prologue Magazine.* National Archives and Records Administration. Vol. 44, No. 1.

Gebhart, Richard. (1993, Summer). Reluctant Acceptance of Wireless Use on the Great Lakes. *Inland Seas.* Vol. 42, No. 2.

Hayes, James. (2012, Mar. 27). Titanic's Legacy to Communications. *Engineering and Technology Magazine.* Vol. 7 Issue 3.

History :: 1912 :: The Sinking of the Titanic. (2012, April) *Cybertelecom Federal Internet Law & Policy An Educational Project Website.* See http://www.cybertelecom.org/notes/history_wireless_earlyreg12t.htm.

Hornberger, Richard L. (1995). Navigational Warnings and Safety at Sea. Navigation Information Services Defense Mapping Agency. U.S. Department of Defense National Geospatial Intelligence Agency. Publication 105. See http://msi.nga.mil/MSISiteContent/StaticFiles/NAV_PUBS/APC/Pub105/105article.pdf.

Howeth, Capt. Linwood S. USN (Retired). (1963). *History of Communications-Electronics in the United States Navy.* Washington: Bureau Of Ships And Office Of Naval History.

Hughes, Michael and Bosworth, Katherine. (2012). *Titanic Calling: Wireless Communications During the Great Disaster.* Oxford: Bodleian Library, University of Oxford.

Important Events in Radio Telegraphy. (1916). Washington: U.S. Department of Commerce, Bureau of Navigation.

International Ice Patrol Website. (2012). U.S. Department of Homeland Security, U.S. Coast Guard. See http://www.navcen.uscg.gov/?pageName=IIPHome.

Kuntz, Tom Ed. (1998). *The Titanic Disaster Hearings: the Official Transcripts of the 1912 U.S. Senate Investigation*. New York: Pocket Books.

Lane, Allison. (2004, Aug. 31). The Impact of Titanic Upon Maritime Law.-see *encyclopedia titanic Website.*

Lasar, Matthew. (2011, July 7). How The Titanic Disaster Pushed Uncle Sam To "Rule The Air". *Ars Technica Internet Magazine.* See http://arstechnica.com/tech-policy/2011/07/did-the-titanic-disaster-let-uncle-sam-take-over-the-airwaves/.

Lord, Walter. (1955). *A Night to Remember.* New York: Bantam Books.

Lord, Walter. (1998). *The Night Lives On: The Untold Stories & Secrets Behind the Sinking of the Unsinkable Ship-Titanic.* London: Penguin.

Lorenzi, Rossella. (2012, Mar. 9). Titanic Wreck Site Mapped. *Discovery News.* See http://news.discovery.com/history/map-titanic-site-120309.html.

The Loss of the "Volturno". (1913, Oct. 25). *Literary Digest.* Retrieved at http://www.searlecanada.org/volturno/volturno05.html.

Lovelace, Virginia Utermohlen. (2010). *Dots and Dashes - Adventures at the Dawn of the Wireless Age.* Ithaca, New York: VU Books.

Marconi, Guglielmo. (1912, June). Wireless and the *Titanic. The World's Work*. New York: Doubleday, Page and Company.

McEwen, Neal. (1999). SOS, CQD and the History of Maritime Distress Calls. *The Telegraph Office Magazine*. Vol. II, Issue 1.

Murphy, Donald L. (2011). International Ice Patrol's Iceberg Counts 1900-2011. Appendix D to *Report of the International Ice Patrol in the North Atlantic, Season of 2011, Bulletin No. 97.*

Navigation Laws of the United States 1919, (1920). Department of Commerce, Bureau of Navigation. Washington: U.S. Government Printing Office.

Paton, Richard USCGR (Ret). (2012, April). Radio's Role in the Titanic Disaster. *QST*. American Radio Relay League.

Peltz, Robert D. (1999, Fall). The Titanic's Legacy: The History and Legal Developments Following the World's Most Famous Maritime Disaster. *University of San Francisco Maritime Law Journal*. Vol. 12, Issue 1.

Proceedings of the IEEE. Scanning Our Past-Proceedings of the IEEE Through 100 Years. Institute of Electrical and Electronics Engineers.

__(2012, Jan.). Proceeding Through 100 Years.

__(2012, Feb.). 1913-1919.

__(2012, Mar.). 1920-1929.

__(2012, April). 1930-1939.

Proceedings of the Institute of Radio Engineers:

__(1913). Marriott, Robert. Radio Operation by Steamship Companies. Vol. I Part 2.

__(1914). Marriott, Robert. Specifications for Steamship Radio Equipment. Vol. 2 No. 2.

__(1914). Graves, V. Ford. The Radio Operator Problem. Vol. 2 No. 3.

__(1914). Sarnoff, David. Radio Traffic. Vol. 2 No. 3.

Report of the Hydrographer. (1912, Sept. 11). U.S. Navy Hydrographic Office. *Annual Reports of the Navy Department for the Fiscal Year 1912*. Washington: Government Printing Office, 1913. See U.S. Navy Historical Center at http://www.history.navy.mil/faqs/faq94-1.htm.

Safety and Shipping 1912-2012 From Titanic to Costa Concordia – An Insurer's Perspective. (2012, March). Hamburg: Allianz Global Corporate & Specialty.

Same Old Slip -- Claim: The Titanic was the first ship to use "SOS" as a distress call. (2012, April 13). '*Snopes-Rumor Has It' Website*. See http://www.snopes.com/history/titanic/sos.asp.

Selman, Tony. (2012, April 10). Radio Amateur Stations Operating Over Titanic Anniversary Period. *The Radio Officers Association Website*. See http://www.radioofficers.com/.

Spurgeon, Arthur (1913). *The Burning of the "Volturno"*. London: Cassell and Company.

Titanic related websites:

__*encyclopedia titanica*. Phil Hind. Research articles on passengers and crew of Titanic and related topics. See http://www.encyclopedia-titanica.org/.

__*Marconi Calling*. Marconi plc. Includes extensive Titanic related material held in the Marconi plc archive. See http://www.marconicalling.co.uk/.

__*Marconigraph*. Parks Stephenson. A forum for leading researchers in maritime history with a section devoted to Titanic. See http://marconigraph.com/.

__*The RMS Titanic Radio Page*. Glenn Dunstan. Specializing in the radio aspects

of the Titanic disaster. See http://www.hf.ro/.

__*Titanic Inquiry Project*. Rob Ottmers. Includes full transcripts of the U.S. and British Inquiries. See http://www.titanicinquiry.org/.

__*Steamship Historical Society of America: Titanic Resource Center*. Resource links and original documents. See http://www.sshsa.org/knowledge_ctr/titanic.html.

__*Titanic Heroes: Officers' Bridge and Wireless Shack*. See http://www.titanic-lore.info/.

__*Titanic Historical Society*. A premier source for Titanic and White Star Line information. See http://www.titanichistoricalsociety.org/.

The Titanic Reports: The Official Conclusions of the 1912 Inquiries Into the Titanic Disaster by the U.S. Senate and the British Wreck Commissioner. (2008). St. Petersburg, Florida: Red and Black Publishers.

Turnbull, G.E. (1913) Distress Signalling. *The Yearbook of Wireless Telegraphy and Telephony, 1913*. London: St. Catherine Press for Marconi Wireless Press Agency, Ltd.

Wade, Wyn Craig. (1986). *The Titanic – End of a Dream*. New York: Penguin Books.

Wells, Andrew. (2012, April). A Night To Forget? *History Today*.

White, Thomas H. (2012) *United States Early Radio History*. Searchable articles and reference materials on U.S. radio including many related to Titanic. See http://earlyradiohistory.us/.

Nineteen Wrecks Within A Month. (1913, Dec.). *Wireless Age*.

Young, LT Stephanie. (2012, April 15). 100 Years After Titanic, Ice Patrol Ensures Safety on the Seas. *Coast Guard Compass*. U.S. Coast Guard.

ABOUT THE AUTHORS

David and Julia Bart live near Chicago. They are graduates of the University of Chicago (David: BA, MBA: Julia: BA) and Concordia University (Julia: MA). David handles corporate finance and valuation matters in complex commercial litigation and bankruptcy cases. Julia teaches elementary school and is a reading specialist. They have maintained a lifelong and highly varied range of interests in electronics history, and they have published many articles about telegraph, radio and broadcasting history. David is a Board member of the Antique Wireless Association, the Museum of Broadcast Communications in Chicago, the Radio Club of America and the Antique Radio Club of Illinois. He is also a Corresponding Member of the IEEE History Committee and Chairman of the RCA Historical Committee.

David has made presentations to the New York Historical Society, the American Association of Physics Teachers and American Association for the Advancement of Science Joint AAPT/AAAS Meetings, the Antique Wireless Association and the Radio Club of America.

Julia is a contributing editor and advisor to the AWA Review and is Editor for the Antique Radio Club of Illinois' publications. A past Treasurer of ARCI, Julia plays an active role as a volunteer and advisor to the Board of Directors. Julia also provides advisory services to the Antique Wireless Association and has coauthored several peer-reviewed articles for the AWA and IEEE.

David and Julia's work on the IEEE Edison Medal and the IEEE Medal of Honor is included on the Institute of Electrical and Electronics Engineers' Global History Network website.

NOTES

1 See section on "*Titanic* Changed Radio Forever" and also History::1912, 2012; Howeth, 1963; McEwen, 1999; Lasar, 2011; Same Old Slip, 2012; Turnbull, 1913.

2 See McEwen, 1999; Same Old Slip, 2012.

3 For complete descriptions of Jack Binns and the *Republic*, see Caddell, 1924; Lovelace, 2010.

4 For complete descriptions of the *Titanic's* wireless radio experiences, see Bride, 1912; Lord 1955 & 1998. For complete transcriptions of the wireless traffic related to *Titanic*, see Booth, 1993 and Hughes, 2012.

5 For complete descriptions of the *Titanic's* wireless radio experiences, see Bride, 1912; Lord 1955 & 1998; Booth, 1993; Hughes, 2012. For biographies of Bride, Cottam and Phillips, see *Titanic* Heroes Website.

6 For complete coverage of the U.S. and British Inquiries, see Wade, 1986. See also Lord, 1955 & 1998; Kuntz, 1998; Peltz, 1999; *Titanic* Reports, 2009; and the *Titanic* Inquiry Project website.

7 For complete discussions about the *Titanic's* impact on maritime law see Lane, 2004; Peltz, 1999; White, 2012. See also History::1912, 2012; Howeth, 1963; McEwen, 1999; Lasar, 2011; Same Old Slip, 2012.

8 See Lane, 2004; Peltz, 1999; White, 2012.

9 See Lane, 2004; Peltz, 1999; White, 2012.

10 See Nineteen, 1913; Gebhart, 1993; Important Events, 1916; McEwen, 1999.

11 Proceedings of the IRE, 1913, Vol. I Part 2.

12 Proceedings of the IRE, 1914, Vol. 2 No. 2.

13 Proceedings of the IRE, 1914, Vol. 2 No. 3.

14 Proceedings of the IRE, 1914, Vol. 2 No. 3.

15 See Proceedings of the IEEE, 2012, Feb. Further note, Richardson went on to pioneer modern mathematical techniques of weather forecasting and is noted for his pioneering work on fractals.

16 See Proceedings of the IEEE, 2012, Feb.

17 See Baarslag, 1935; The Burning of the *Volturno* Website, 2012; Daamen, 2001; Spurgeon, 1913.

18 For more history about the IIP, see Hornberger, 1995; International Ice Patrol Website, 2012; Young, 2012.

19 See Safety and Shipping, 2012. Note, the checked items which highlight the radio related advances in maritime safety were selected by the authors.

Julia and David Bart

The San Francisco Radio Club, Since 1909

Abstract

The San Francisco Radio Club has enjoyed more than a century of the advancing radio art, fraternity and public service, as an exemplar of the Amateur Radio Service at its best. Its technical investigations have explored radio's potentials since 1909. The Club's early days show the enthusiasm with which young men took to the new art, both as a hobby and as professional preparation. It also established, from its beginning, cordial relations with its government regulators, from whom it received the first Amateur Radio license issued by the Federal Radio Commission in 1927. Its members pioneered pre-war VHF work on 5 meters and 2&½ meters, and then 2 meters. The Club adopted the callsign of an early member, W6PW, as its own, for its repeater and field operations. In recent decades it has continued its public service, education, and social activities in the best traditions of amateur radio, on its deep foundations as one of the oldest radio organizations in the world.

In August, 1899 *Lightship 70*, moored nine miles off San Francisco in the fog, signaled to San Francisco's Cliff House that it had sighted the troopship *USS Sherman* returning from the Spanish American War. The ship used an induction coil; the receiver in the Cliff House was a wire and a coherer and an inker. Wireless telegraphy thus sent America's first radio message. Newspaper reports gave rise to national interest in the new mode of communication. Marconi, of course, had been making widely publicized progress in England. Tesla, too, had publicized experiments. But the San Francisco signal ignited local interest and enthusiasm, especially among young experimenters.

The early 1900s witnessed great progress in Navy, Army and commercial wireless. The San Francisco area pioneered much of the new technology:[1]

- Cyril Elwell in Palo Alto works with Poulsen's arc transmitter, 1907.
- Maritime wireless stations appear in San Francisco from 1907 – *e.g.*, the Massie Company's at Land's End.
- The Great White Fleet visits San Francisco in 1908, playing wireless

music on a DeForest Company arc transmitter.
- "Doc" Herrold in 1909 experiments with modulating a spark transmitter, and by 1912 routinely broadcasts music in San Jose using an arc transmitter.

In and perhaps before 1903, young men in San Francisco followed the earliest nautical and commercial work in the radio art with their own "wireless telegraphy" transmitters and receivers. Home -made induction coils and even doorbell buzzers worked as transmitters (along with automotive ignition spark -coils a little later). Combinations of carbon rods and steel, and coherers, worked fine as detectors of wireless signals, at least at short ranges. Many a telephone lost its earpiece to facilitate amateur experimentation. By 1909, word was out about crystal detectors, particularly carborundum. In San Francisco and elsewhere, men and boys formed clubs to work with like -minded wireless telegraphy experimenters. Their object was to communicate over the air – the "ether" as it was known then – and they did, sometimes to the annoyance of the Navy and others.

School occupied the weekdays of these young amateurs but on Saturday mornings the ether called, to the despair of professional operators. As one DeForest Company station PH operator in 1906 noted in the log:[2]

"8:30 a.m. The combined forces of 3,000 ham factories are bursting forth with their weird codes upon the quietude of this lovely rainy morning."

Landline telegraphers described as "ham" what they heard as a result of bad telegraph key technique – "ham-fisted" operators on the key – and the term migrated to the wireless world. Most wireless operators of the day had been landline telegraphers. The use of the term "ham" for an amateur radio operator likely derives from this usage.

On December 26, 1909 the San Francisco Chronicle reported:[3]

"This is amateur morning in the wireless world. San Francisco and adjoining suburbs alone have between 200 and 300 young wireless operators; amateurs who rank as such principally in name, who are everywhere dotted about the city and country for a stretch of miles that extends way beyond the city and county boundaries."

Wireless clubs initiated the earliest San Francisco area amateur callsigns. They assigned their own members call letters, in imitation of maritime and commercial stations. The Bay Counties Wireless Telegraph Association, in Berkeley, did so as early as 1907.[4] That club assigned "S" as a prefix. Ray Newby, a young but accomplished San Jose wireless amateur, got SEW, after using the self-assigned call EZM. He assisted Charles D. "Doc" Herrold, in San Jose, in some of the first radio broadcasting as early as 1909 (Modern Electrics in 1910 published a photo of the two of them operating a spark station) and Newby later went to sea as a marine operator. Likely earlier than 1906, Bill Larzelere and Ed Stevens were two of the first amateur wireless operators in San Francisco. Barney Osbourne, later W6US, experimented

early in the century and took to the ether in San Francisco about 1908, running 5 KW using the callsign CG.

Hugo Gernsback published the "First Annual Wireless Blue Book of the Wireless Association of America" in May of 1909. He did so in connection with promotion of his new Modern Electrics magazine, and had solicited information about stations. The Bluebook lists nine responding California amateur stations, although hundreds of amateurs operated in California. One listed itself as the "Ozone Wireless Company" in San Francisco. Inasmuch as it used the callsign MJ, those were probably the operator's initials, the common practice of the day. The Blue Book shows MJ operated on 80 meters, a short wavelength for 1909, with a ten-inch spark from his induction coil transmitter (high voltage but not necessarily high power). Most listed sparks were in the one inch or few inches range, although nationally a few stations listed themselves by power, in the fractional kilowatt to two kilowatt range. Ray Newby in San Jose listed himself as EZM with a three-inch spark at 235 meters wavelength.

The San Francisco Radio Club came together in 1909.[5] The Club is the oldest persisting amateur radio organization in the nation and likely the world (although not the first such club to form, even in the Bay Area). Henry W. Dickow started the Club in 1909 as a twelve -year -old boy; R.E. Crowden assumed the presidency of this boys' club. Dickow later edited Pacific Radio News. This evolved into Radio and eventually Audio magazine, still published. He later held amateur radio callsign W6JYN and still later helped to manage the Society of Wireless Pioneers.[6] (Figure 1) The Club seems to have foreseen fewer than 26 amateurs in the City eligible for membership in 1909. For its callsigns, it used the prefix RS for Radio SanFrancisco, and then letters A through Z, e.g., RSC.[7]

A 1924 retrospective noted: "Radio amateurs of San Francisco have long been banded together in an organization known as the San Francisco Radio Club, Inc. The club is one of the oldest and largest of its kind in America, having been founded in 1911"[8] [sic; 1909]. In 1917 Dickow wrote:[9] "In former years

Figure 1. Henry Dickow about 1924, from the 1924 Radio Convention Official Program.

there flourished a radio organization … known as the San Francisco Radio Club, having a membership of about fifteen operators. This club was organized before the U.S. Government laws went into effect and disbanded shortly after… twelve [out of the 15 total club members] successfully passed the … Commercial First Grade examination…" (He refers to the 1912 law (see below) that required amateurs to operate on shorter wavelengths).

From its beginning the Club provided an educational and social forum for young wireless amateurs to work towards professional status in the maritime industry, and to associate with professionals as well. In contrast, the University wireless experiments of the day, from Harvard to Stanford, focused on learning physics, and on engineering applications, albeit farsighted. But from the Gold Rush until recent decades, the maritime industry kept San Francisco's port the busiest on the West Coast. From the first decade of the 20th Century, the Bay Area ether rang with signals of ships and shore stations, including the Navy's first wireless network. The prospect of well paid, adventurous and high profile work as sea -going radio operators powerfully attracted young men of talent, spirit, and a good ear for Morse code, as San Francisco's marine industries prospered. The San Francisco Radio Club facilitated their ambitions.

In 1912, new U.S. law[10] challenged amateur radio. To eliminate conflict between amateur stations and maritime communications, the law's section 15 relegated amateur radio to wavelengths 200 meters and down; i.e., 1,500 KHz and up. Amateur wireless stations may have interfered with Titanic -related communications in April 1912, and certainly with other communications nationwide. Many amateurs earned the enmity of commercial and government organizations. The abuses of some amateurs precipitated this exile to radio Siberia for all. The radio art considered these frequencies, with wavelengths of 200 meters and shorter, to be a wasteland of the unfamiliar, the difficult and the futile. Most maritime stations worked on 600 meter band wavelengths (500 KHz). Amateur wireless stations often did the same – annoyingly, although some worked shorter wavelengths. The 1912 restriction would be like a law today that amateur radio could only use frequencies of five gigahertz (5 GHz) and above. Many, perhaps most, amateur wireless operators turned to other endeavors once they were restricted to shorter wavelengths. For example, M.H. Dodd, who started out in Los Angeles about 1908, operated his station[11] in Nevada until 1912 (Fig. 2). He closed it and sealed it up in 1913, as a result of the wavelength restriction. Only recently found, as if preserved in amber, a museum now displays it.[12]

The 1912 change in the law imposed for the first time licensing and testing on amateur radio operators. The new law also provided for government -assigned callsigns by district. For example, California and some of the western states comprised District Six, with callsigns such as 6HD, while

District One covered New England, with callsigns such as 1XM.

Between 1914 and 1917 amateur radio again flourished, as operators improved techniques to use the newly assigned higher frequencies above today's AM broadcast band. Amateur radio had these "short waves" pretty much to itself. The new vacuum tube, and E. Howard Armstrong's regenerative circuit that it enabled, piqued interest in amateur radio operation. This was especially so because regenerative receivers could resolve very weak and distant signals. The regenerative circuit could also oscillate. Technically adept amateurs could then soon employ vacuum tubes as transmitters that emitted continuous waves. San Francisco enjoyed many radio entrepreneurs, such as Elmer Cunningham and Otis Moorehead (6XJ and 6XP) and George Haller.[13] They concerned themselves way more with profits than with patents. They bootlegged triodes with abandon, much to the annoyance of Lee de Forest. Still, most amateurs used spark, and crystal detectors.

Figure 2 M.H. Dodd's 1912 Nevada station; he started out in Los Angeles.

In the midst of this techno -ferment, the San Francisco Radio Club reinstituted itself in January 1916, with 36 members. In 1917 former President Crowden, by then a Marconi operator, noted that several of the original 1909 era members participated in the revived San Francisco Radio Club. The Club published a "Yearbook" in 1916. The U.S. Department of Commerce published extracts from the Yearbook in an issue of its Radio Service Bulletin,[14] as a model for other clubs. Surely San Francisco Radio Inspector Lt. Ellery Stone arranged the publication of the extracts (Fig. 3 – he had been an amateur since 1910, licensed as 6YE until January, 1915[15]).

Extracts from the Yearbook of the San Francisco Radio Club

Object and Purpose

During the early part of January, 1916, a number of prominent commercial and experiment radio operators of San Francisco met in order to discuss the possibility of organizing a radio club in that city. The number of enthusiastic operators barely reached the dozen mark, but regardless of the small number present, a prosperous future for a radio organization was foreseen, and the necessary steps toward founding an organization were taken.

Figure 3 Lt Ellery Stone, U.S.N., Radio Inspector; he later authored a highly regarded book on radio engineering and rose to the rank of Admiral.

Radio operators throughout the city were notified of the undertaking and were urged to give all possible support to insure a huge success.

A meeting was held and the number of responders was surprising large. A constitution was framed, submitted for approval at a later date, and finally signed by 15 charter members. The situation was then well in hand, and the membership of the club increased rapidly as the weeks passed by, until at the present time 36 radio men are in possession of the membership card.

Membership and Qualifications

The membership comprises:

(a) Members who either hold a first-grade commercial license or better or who have passed the club examination of that grade.

(b) Associates who are interested in radio communication.

Associate member[s] desiring to become full members are examined when their capability permits, and if they are successful in passing the club examination they are transferred from the grade of associate to member. A certificate of skill will be issued to all associates who successfully pass the examination.

Meetings

Meetings of the San Francisco Radio Club are held every Friday evening at the club room, 737 Shrader Street, at 8 o'clock.

The four meetings per month comprise an experiment meeting, a social meeting, and two business meetings. At the experiment meeting various electrical and radio apparatus are demonstrated. Experiments impossible for a single experimenter to perform have been made possible by the cooperation of the members.

Advantages of Membership

The San Francisco Radio Club offers many distinct advantages to its members. Radio men in all grades of experience come together, exchange ideas, relate experiences, benefit by interesting and educational lectures, and learn the methods of good speech delivery. Commercial operators come into contact with amateur operators and experimenters; interference between stations is reduced to a minimum, and the maximum of efficiency is secured from the experimenters' apparatus with the aid of accurately calibrated measuring instruments which the club possesses.

Privately owned stations are tuned to resonance to comply with the regulations of the Department of Commerce without charge to the owner.

The Club, in a typical technical event in November 1916 mooted a debate: "Resolved, The Audion Is Superior To The Crystal Detector." The Audion proponents got the better of the issue with almost 100 "enthusiasts" present. [16]

Starting in January 1917 the Club published the first issue of *Pacific Radio News* (Figure 4). Henry W. Dickow was the principal of the Club and the magazine. Friendly Radio Inspector Stone no doubt assigned Dickow's callsign 6HD, his initials. Dickow went on to a distinguished career and the magazine

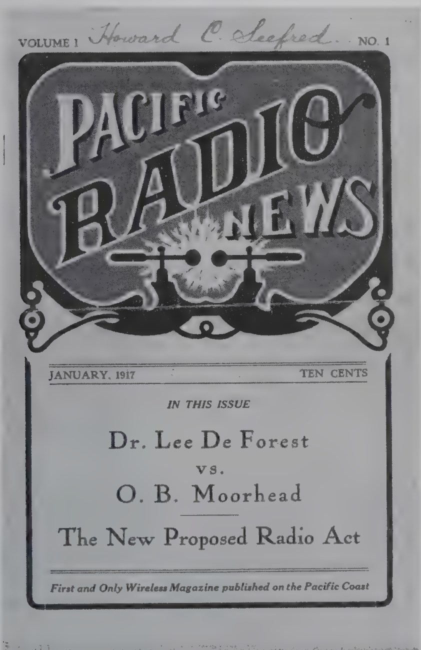


Figure 4 Pacific Radio News, January 1917 First Issue; it followed on the Club's 1916 Yearbook.

became *Radio*, as owned and published by him, in the 1920s.

Dickow was not above promotional doggerel for the magazine:

"The San Francisco Radio Club, Its members tried and true,

Will furnish all the latest news, That may appeal to you."

The San Francisco Radio Club flourished in 1916 and 1917. Nearly a hundred members had signed up by 1917, according to Dickow. Commercial and maritime wireless companies already employed many members. Members had to pass a test equivalent to the U.S. Department of Commerce First Grade Commercial examination. The Club then considered applicants who also showed Morse code proficiency. Use of the Club's measuring instruments, wave-meters and the like avoided interference to commercial and naval operations. Prominent speakers addressed the Club and the Club printed the lectures. The Club's initiation fee was $1 and monthly dues 25 cents (amounting to $3 a year, equal to about $50 today). The Club maintained a clubroom in the City.

There was much official praise for the Club, in an era of newly regulated amateur radio operation. Inspector Stone (photo[17] Fig. 3) noted that only the San Francisco Radio Club and the Institute of Radio Engineers in New York had published Yearbooks. According to Dickow in 1917: "The task of tuning stations to resonance has met with great approval by the local Radio Inspectors…" Bureau of Navigation Radio Engineer V. Ford Greaves wrote:

"I ... desire to congratulate you and the members of your club on your excellent organization...."

In 1917, the Club officers were:

- H. W. Dickow, President (6HD in 1913, later W6JYN).
- D. B. McGown, Vice-President – later in 1921, Assistant Radio Inspector.
- H. R. Lee, Secretary – Treasurer.
- T. J. Ryan, Sergeant –at -Arms – later in 1919 also a Club Officer, and an Army Sergeant stationed at the Presidio, active in wireless there.
- C. M. Heaney, Examining Officer
- H. J. Malarin, Examining Officer – He was later a radio dealer in 1921. Laurence Malarin ("LM"), likely his brother, was the legendary manager of United Wireless and American Marconi in San Francisco (later RCA).
- Also, W.D. Hewartson, later W6NCB, helped revived the Club in 1916. (He, like others, continued his Club membership well into the 1940s).

But soon enough, World War One – "The War to End All Wars" – almost ended amateur radio as well. In April 1917, the U.S. Government shut down *all* radio stations, receiving as well as transmitting; *all* antennas had to come down. [18] The fear of German spies pervaded the country. The San Francisco Radio Club, however, held itself together under the leadership of Francis K. Teeter, Jr., (Fig. 5) with only four active members. Many amateurs enlisted in the armed forces. Most if not all other amateur wireless clubs and all non-governmental stations went quiet for the duration: QRT in the wireless telegraphers' code.

After victory in November 1918, amateurs looked to getting back on the air, especially with the newly available vacuum tubes. The Navy, however, wanted to maintain its wartime total control. Commercial interests won out, also liberating amateur radio from Navy suppression.

The San Francisco Radio Club revived again after World War One. It incorporated[19] on May 16, 1919, looking to a long future. It did so anticipating the lifting of the ban on amateur operation, which occurred in September 1919, effective October 1, 1919, according to the Radio Service Bulletin.[20] Stations still had to get re-licensed. The Club's purposes in 1919, exactly as stated in its incorporation papers, and which it achieved for decades, were:

- To promote among its members the practice of, and interest in Radio Communication;
- To advance the science of Radio Communication among its members;
- To have club rooms and halls for its members;
- To construct and maintain for

Figure 5. Francis K. Teeter, Jr. in the early 1920s serving in the Forest Service.

the educational advancement of its members Radio apparatus and equipment;
- To conduct lectures and demonstrations and give courses in Radio Communication and construction of apparatus;
- To hold social functions;
- To acquire a library and current periodical literature on the science of Radio Communication.

The incorporating amateurs in 1919 were:
- Adolph W. Honing, 516 7th Avenue.
- William Joseph Henry, 554 11th Avenue (who went to sea in 1921 on "one of the Panama boats.")
- Francis K. Teeter, Jr., 365A 11th Avenue (who had kept the Club alive during the war).
- Eugene L. Chaix, 2056 Bush Street.
- Sergeant Thomas J. Ryan, 349 7th Avenue (a 1917 officer).

Radio -telephone operation came to the Club in 1920, courtesy of Lee de Forest who had been broadcasting in San Francisco and then Berkeley since 1919. Leo J. Meyberg, 6XG, a radio dealer who owned broadcast station KDN from 1921, made the arrangements for the Club. For experimental use, the radiophone broadcast Club announcements and promoted the Club on the air by way of "club propaganda." [21] This may well have been a proof -of -concept trial for Meyberg's broadcasting station. That same summer, Hiram Percy Maxim, of the then six -year -old American Radio Relay League, gave the Club "an interesting address on the history of the A.R.R.L." [22] Maxim held the Special Amateur callsign of 1ZM as of March, 1915.

A Club officer, Harrison Holliway, 6BN, frequently used his amateur radio -telephone ('phone) station in 1920 to broadcast music "for the sheer pleasure of it" (Fig. 6)[23]. His station established a record for voice amateur communications with a contact of 1,800 miles into Vancouver, B.C., Canada. He had started out in 1911 (at age 11) with a carborundum detector, and he had gone to sea and to Stanford. By 1924 Holliway was the manager of San Francisco's new powerhouse broadcaster (50 watts of Westinghouse!), KFRC.[24]

The Club put on San Francisco's first radio convention (held in in 1920), and according to program of the later 1924 radio show, which noted: "Radio amateurs of San Francisco have long been banded together *** The first radio show held in San Francisco, a number of years ago, was entirely conducted by the San Francisco Radio Club." The Club displayed equipment from Francis McCarty's radio -telephone enterprise, which he started in1902, inductors and detectors and the like, already antique

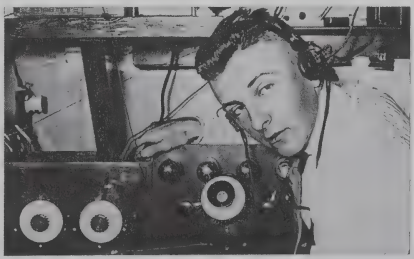


Figure 6. Harrison Holliway, 6BN, San Francisco in 1920; he later became an early broadcast radio personality.

by 1920. The Radio Service Bulletins of 1920 carried regular updates on the progress of the preparations for the radio show. In the October issue of *Pacific Radio News*, the Club placed a large advertisement inviting participation in "The First Pacific Coast Radio Convention." *Pacific Radio News*, after the show, declared it to be the great success it was, after having promoted it (and its Radio Banquet and Radio Ball) extensively – *e.g.*, "The Radio Convention – a Stepping Stone to Progress." [25] The December 1920 issue featured a two page photograph of one third of the 580 attendees and a detailed report. This included the titles of musical numbers played at the Ball, received from a hotel on a DeForest radio and presented through "a Magnovox" (the newly invented "loudspeaker"): *e.g.*, Oscillating Fox Trot, Synchronous Waltz, Amplified One Step and Loose Coupled Waltz.

Building on the success of the 1920 Radio Convention, the Club resolved in January 1921 to acquire a big blackboard for diagrams and two receivers (a regenerative set and a long -wave honeycomb coil set), to overhaul the radio -telephone and put up a new antenna, and to put a complete station on the air.[26]

By 1921, Francis K. Teeter, Jr. had pioneered use of radio by the U.S. Forest Service, calling on amateur operators to come to work for the Service. He used World War One radio equipment from the Army Air Service for both air and ground operation (photo nearby[27] Fig. 5). Nonetheless homebrew equipment and home construction defined state -of -the -amateur -art in those days: *Pacific Radio News* featured a vacuum tube transmitter of 20 Watts power, continuous wave (CW) for Morse code and radio-telephone. Like much else amateur, it was Do-It-Yourself.

Club officer nominations for 1921-'22 included Dickow, Clarence Schomaker (callsign 6AET) and Sydney J. Fass. A graphic of Clarence Schomaker's membership certificate[28] appears below. (Fig. 7). It is signed by Teeter as President. Sydney Fass had been active since 1909, "MU", later W6N2. He also served as a seagoing wireless operator in 1911 at age 16, and then shore-side at United Wireless station PM in Eureka, California. He served in the Navy for 33 years and in both wars and retired as a Commander. He then established one of the largest radio and electronics retailers in San Francisco in the 1950s.

By 1922 advanced amateur stations had achieved considerable sophistication. A series of photos that come from a photo album[29] of a Canadian by the name of C. West (callsign 5CN) Vancouver, B.C., Canada appears nearby. It


CERTIFICATE OF MEMBERSHIP

San Francisco Radio Club

A MEMBERSHIP ORGANIZATION

Incorporating Commercial and Experimental Radio Operators

This is to Certify that Clarence Schomaker

a radio operator, is an active member of the SAN FRANCISCO RADIO CLUB, Inc., and he agrees hereby as shown by his signature, to observe all the rules and regulations of said organization, promote the interests of Radio Communication, and at all times to observe the laws of Radio Communication of the United States.

Approved PRESIDENT

SECRETARY

Signed by MEMBER

Date Issued

Figure 7 Clarence Schomaker's 1920 SFRC membership certificate (author's collection).

seems that some amateurs, who had the money to do it, enjoyed trading station photos, both in North America and in Europe. Of course, most amateurs had neither the time nor the funds to create extensive stations and photograph them as well. It was in these years, however, that the exchange of postal verifications of radio contact, QSL cards, became common, initially as penny postcards

A San Francisco station features prominently in the C. West album: 6AWT. Bart Molinari, callsign 6AWT, was the American Radio Relay League (ARRL) 1924 Hoover Cup Winner for Best Amateur Station in the United States. Cage antennas on towers at 6AWT put out the signal from Molinari's state of the art station, Fig. 8. In the 1930s, Philo Farnsworth, the San Francisco inventor of electronic television, employed Molinari as his Chief Engineer at Farnsworth's Green Street laboratory.[30]

Figure 8. Bart Molinari's 6AWT cage antennas; photo from C. West 5CN album (author's collection).

Washington State's 7NJ enjoyed the attentions of a professional photographer, Fig. 9. Yerington, Nevada's 6UO (Fig. 10) features a DeForest Company "Unit" or Interpanel modular receiver and Western Electric audio amplifier for a horn speaker. Many amateurs of the day forwarded messages around the country, in relay operation; hence the typewriter for "traffic." The 6UO photo discloses the name of the operator, Bill Heade, and shows his vacuum tube transmitter.

Before 1927, the U.S. Department of Commerce regulated the ether and issued station licenses. Radio advanced into a new legal era with the Radio Act of 1927.[31] The new industry of broadcasting demanded regulation of interference and more than the two frequencies to which it had been relegated. The new law established the Federal Radio Commission (F.R.C., later the F.C.C.), it reallocated frequencies, and limited operating times, and required operating licenses. The San Francisco Radio Club, Inc. applied early for a license from the F.R.C., for itself as a club. It apparently got the very first one issued, perhaps as a result of its continuing cordial relations with its

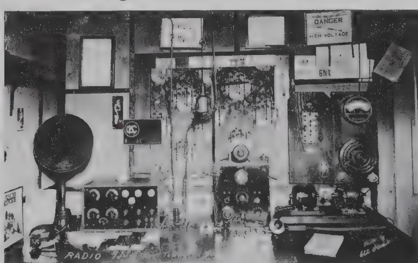


Figure 9. 7NJ in Washington State, circa 1922; professional photo from C. West 5CN album.

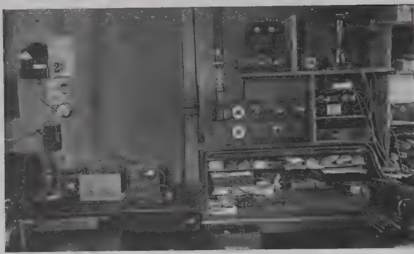


Figure 10. 6UO in Nevada, June 29, 1923; photo from C. West 5CN album.

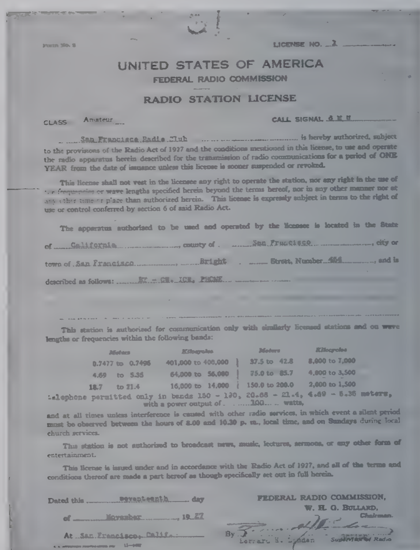
regulators. This license (Fig. 11), by the Federal Radio Commission, signed by Bernard Linden, the San Francisco Radio Inspector, issued on November 17, 1927 as "License No. 1." A photo of Inspector Linden[32] (Figure 12) appears nearby. Linden had given a talk about radio's future to the Club a few years earlier; the Club enjoyed friendly Inspectors.

The F.R.C. issued 6MU as callsign for the new Club station, located at 454 Bright Street, in San Francisco. The license specifically provides for:

- Power Authorized: 100 Watts.
- Bands Authorized: 70 cm (400+ MHz), 5 meters (56 MHz), 15 meters, 40 meters, 80 meters & 160 meters (1,500 KHz to 2 MHz).
- Phone operation only in 70 cm, 15 meters & 160 meters.
- Term of license: one year.
- Silent Hours, 8 PM to 10:30 PM if interfering.
- No news, music, lectures, sermons or entertainment.

Standard license conditions of the time for amateur stations called for silent hours and precluded broadcasting. For 1927, the frequency range stands out: 160 meters to 70 cm, *i.e.*, 1,500 KHz to 400 MHz. To generate a 400 MHz signal in 1927 required considerable technical skill.

The first three decades of the San Francisco Radio Club laid a solid social and technical foundation for the next seven. In the 1930s it flourished despite the Depression. It participated in the ARRL Amateur Radio Emergency Corps before World War Two. It held *and filmed* summer Field Day exercises in 1940 and 1941 and thereafter. It chose as its site the highest point in San Francisco, Mt. Davidson, in the south of the city. Field Day also became the subject of local "ham humor" – see Figure 13. Social events played a large role in the Club. On one occasion in the 1930s a New Zealand amateur, a distant station



LICENSE NO. 1

UNITED STATES OF AMERICA
FEDERAL RADIO COMMISSION

RADIO STATION LICENSE

CLASS Amateur CALL SIGNAL 6 M U

San Francisco Radio Club is hereby authorized, subject to the provisions of the Radio Act of 1927 and the conditions mentioned in this license, to use and operate the radio apparatus herein described for the transmission of radio communications for a period of ONE YEAR from the date of issuance unless this license is sooner suspended or revoked.

This license shall not vest in the licensee any right to operate the station, nor any right in the use of the frequencies or wave lengths specified herein beyond the terms hereof, nor in any other manner nor at any other time or place than authorized herein. This license is expressly subject in terms to the right of use or control conferred by section 6 of said Radio Act.

The apparatus authorized to be used and operated by the licensee is located in the State of California, county of San Francisco, city or town of San Francisco, Bright Street, Number 454, and is described as follows: ST - CW, ICW, PHONE

This station is authorized for communication only with similarly licensed stations and on wave lengths or frequencies within the following bands:

Meters	Kilocycles	Meters	Kilocycles
0.7477 to 0.7496	401,000 to 400,000	37.5 to 42.8	8,000 to 7,000
4.69 to 5.35	64,000 to 56,000	75.0 to 85.7	4,000 to 3,500
18.7 to 21.4	16,000 to 14,000	150.0 to 200.0	2,000 to 1,500

Telephone permitted only in bands 150 - 200, 20.68 - 21.4, 4.69 - 5.35 meters, with a power output of 100 watts,

and at all times unless interference is caused with other radio services, in which event a silent period must be observed between the hours of 8.00 and 10.30 p. m., local time, and on Sundays during local church services.

This station is not authorized to broadcast news, music, lectures, sermons, or any other form of entertainment.

This license is issued under and in accordance with the Radio Act of 1927, and all of the terms and conditions thereof are made a part hereof as though specifically set out in full herein.

Dated this seventeenth day of November, 19 27
At San Francisco, Calif.

FEDERAL RADIO COMMISSION,
W. H. G. BULLARD,
Chairman.

By Bernard H. Linden Supervisor of Radio

Figure 11. SFRC station license, 1927, 6MU, "License No. 1"; courtesy of Paul Merrill, W7IV, via Ed Silvester, NI6S and Dave Billeci, WA6UHA, SFRC.

Figure 12. Radio Inspector Bernard Linden of San Francisco; from the 1924 Radio Convention Official Program.

("DX") frequently contacted, visited San Francisco, to a great welcome by the Club, and he extended his visit considerably. But "the San Francisco gang" also arranged to have amateurs across the country welcome and host him, as they did.[35]

Frank Jones, a noted engineer and technical writer, participated in Club activities. He designed the first working five -meter (56 MHz) communications system in 1936, for use in the construction of the San Francisco Bay Bridge. He was also responsible for the Radio Handbook published annually in Palo Alto, often known as the West Coast Handbook to distinguish it from the Handbook of the American Radio Relay League (ARRL).

Figure 13. Early Field Day cartoon by Les Funston, W6QQU from Amateur Radio Defense published in 1941.

Some other prominent members of the Club before the War (screen-capture photos nearby from the Field Day 16 -mm movies) included:

- William A. (Bill) Ladley, W6RBQ (Fig. 14). He owned the Pacific Felt Company and the movies feature a company truck as the mobile communications center. He was a VHF enthusiast who broke two-meter distance records; the nearby mountains *Diablo* and *Tamalpais* helped. He served as an ARRL Section manager in 1945.
- Wilbur E. ("Bip") Bachman, W6BIP (Fig. 15) born in 1911, operated pre-war on the 2&½ meter band, 112 MHz as an early VHF enthusiast. He put together a mobile VHF rig with its own tower. Bip enjoyed DX as a member of the Northern California DX Club (NCDXC); he also travelled to Greenland. He served as vice -president of the San Francisco Radio Club when the FCC awarded him the first Extra Class license in the Club. As an attendee of the 1965 ARRL National Convention, Club records show that he was pleased to win a HeathKit as a door prize. He remained active

Figure 14. Bill Ladley, W6RBQ, seated at an early Field Day (this and similar images are screen captures from the SFRC movies which were probably shot by Russ Hanlon, W6KJ).

and visited the Club at 89 years of age in 1999.

- R.S. (Rus) Hanlon, W6KJ, preserved and probably shot and edited the Club's 1940s Field Day movies. The movies also feature

Figure 15. Wilbur E. ("Bip") Bachman, W6BIP on Field Day, with his mobile and portable 2&½ meter, 112 MHz rig.

other prominent California amateur stations. He retired from the wartime Navy as a Lt. Commander.

- John L. Stevens, W6PW (Fig. 16), served as President of the Club at one time. He first appears in *Radio Amateur Call Book* magazine in 1932.[36] He built rigs for others and participated in record -breaking five-meter contacts in 1932. He and his callsign last appear in the *Callbook* in 1955. The Club adopted his callsign as its own in 1957.
- Kenneth E. Hughes, W6CIS (Fig. 17), an active operator before and

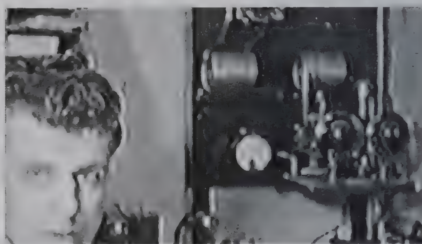


Figure 16. John L. Stevens, W6PW about 1941; the Club adopted his callsign in 1957.

after the War, including Field Day. He served as the ARRL Section Manager early in the War, and later as the ARRL Pacific Region Director. Later in the War he served in the Pacific Theater of operations. His daughter Joan Porath remembers his amateur radio operations

Figure 17. Kenneth E. Hughes, W6CIS, foreground, in the 1948 Field Day truck.

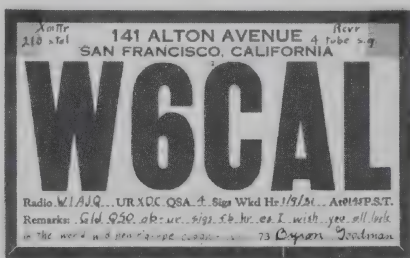
well, and she has been very helpful in identifying images.

- Jack Slater, W6NF (Fig. 18), also retired from the Navy after the War. In the movies, his wife ("XYL" – former YL or Young Lady) has to drag him away from his radio by the ear, in a dramatization. Like many amateurs of the day, he used a Pilot AC Superwasp receiver. More amateurs in the late 1920s and well into the 1930s used this regenerative radio than any other. This was so until the advent of affordable receivers using Armstrong's superheterodyne circuit (the superhets) such as the Hammerlund Comet Pro, one of the earliest. Slater's transmitter, like that of W6PW, was a breadboard with a couple of vacuum tubes, almost low power (QRP) by today's standards.
- Clayton Bane, W6WB, also acted as an ARRL official. He too visited the Club when he was in his late eighties about 1999.

Figure 18 Jack Slater, W6NF, and his XYL about to haul him out of the shack by his ear.

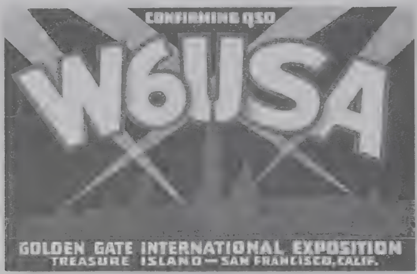
- Byron Goodman, W6CAL, used a homebrew one vacuum tube transmitter employing a 210 tube and four tube receiver.
- Some of the other Presidents of the period were Hal Ayers, W6NGV, who worked in San Francisco at Henry Dickow's *Radio* magazine; Sam C. Van Liew, W6CVP; and A.W. Fonseca, W6NYQ, a ten-meter phone enthusiast and telephone company executive who arranged the Club's technical presentations.

In 1939, San Francisco hosted a World's Fair on the newly created Treasure Island in the Bay, the Golden Gate Exposition. It featured the operating amateur radio station W6USA. Club members Bob Hanson, W6MPC and Johnny Werner, W6ONQ, among others, operated it. W6USA issued a special event QSL card.



Immediately before the War, the San Francisco Radio Club stood out for the quality of its membership (224 at one point) and the success of its organization. In 1941 an article about it appeared in *Amateur Radio Defense* magazine, published in San Francisco by Henry Dickow. It was titled: "Success Secrets of a Radio Club."[37] It listed eight of them:

1. Age 21 and over for membership but some open meetings;
2. Meetings regularly at the same restaurant
3. which means a free room in return for members buying dinner;



4. Technical presentations of high quality;
5. Extensive publicity, passing the hat to cover this cost;
6. No discussion of finances during meetings;
7. No dues and no initiation fees;
8. Meetings are first social at dinner, and then technical.

The Club membership in 1941 looks to be predominantly successful businessmen. A few wives, sometimes licensed amateurs, participated in social activities. Minorities do not appear in Club photographs or records of the day, but then it was not until after the Second World War that there was much minority interest in amateur radio, often as a result of war -time training. The Club did not consider itself elitist, although it acknowledged the characterization. To this day, members vote on new members, although the Club does not discriminate in any way. Still, its members from its first decades have

Figure 19 Hallicrafters all band racked wide coverage dream receiver(s) in1941; from an advertisement (with emendations).

been the cream of the hobby. But only if you were rich as Croesus could you afford what Hallicrafters advertised in 1941 as the Complete Radio Receiving Station, 2730 meters to 1.8 meters AM and FM (that is to say, 100 KHz to 150 MHz); Hallicrafters racked an SX-28,

Figure 20 Abbott TR-4 Transceiver for 2&½ meters, 112 MHz of the type used in WERS in San Francisco (author's collection).

an S-27, and an S-22R together for this advertisement (Fig 19).

The years of radio silence during World War Two were in many ways the Club's finest hour. Although it was necessarily dormant, many of its members served with distinction in the armed forces. San Francisco amateurs also participated in the War Emergency Radio Service (WERS) on 2&½ meters, 112 MHz, which the Club had pioneered. The City of San Francisco provided WERS operators with 35 Abbott TR-4 transceivers for 112 MHz operations (Fig 20). The San Francisco WERS stations used the collective callsign KGCW, and presumably tactical identifiers. Sixty or more San Francisco and Oakland amateur radio operators participated in WERS.[38]

After victory in the Second World War, the San Francisco Radio Club resumed activity. It held its first post-war meeting in February 1946. Its membership soon exceeded 100. Field Day 1948 features in the movies. War surplus permitted mobile operation in Jeeps; it also soon supplied many high quality and easily converted receivers and transmitters to the amateur ranks.

In 1957, the San Francisco Radio Club adopted the callsign of an early member, John L. Stevens, W6PW as its Club station callsign. An early Club QSL card notes its phonetics: "six peanut whistle."[39] The Club's two-meter repeater has identified itself as W6PW for many years. The two main VHF repeaters in San Francisco are W6PW, known as Poppa, and the Telephone Pioneers' W6TP, known as Mother. The Club also has operated a multiband station W6PW in the Veterans Administration hospital, in which it meets monthly. That VA station is now W6SF.

Amateur Radio has always been a social pastime. The Club has hosted a Christmas and Holiday Party every year since 1916. The Club has held meetings, nets and social events for a century. In recent years, this has included an annual "pasta feed," and annual Field Day cookouts. One tradition that fell by the wayside, to the regret of many, was the venue of the 1960s for Club meetings: the Bergermeister Brewery.

Members of the Club have also devoted themselves to continuing public service for decades. This has included:

- Field Day every peacetime year since the 1930s, including one visible light Morse code exchange with the Mt. Diablo Amateur Radio Club (W6CX) on Mt. Diablo in Contra Costa County, some 30 miles distant from the W6PW Field Day site in the Marin headlands. Field Day has provided recent opportunities to introduce young people to the amateur radio hobby (Fig. 21 – 1990s). The Mt. Diablo club and the SFRC have jointly hosted a summer camping trip for many years with field operations.
- Typical of its ongoing public service, putting up the antennas for the amateur radio station at a recreation center for the handicapped in 1967, as noted in *Popular Electronics*.[40]

- Communications Assistance at the 1984 Democratic National Convention in San Francisco.[41]
- Member-provided Amateur Radio assistance in the 1989 San Francisco Earthquake and to the Red Cross in New York in disaster recovery after the terrorist enormity of September 11, 2001. [42]

Figure 21 1990s Field Day, Ms. Keller at the microphone of W6PW, in the Presidio of San Francisco (KRON-TV image).

- Support of ARRL ARES and the San Francisco Auxiliary Communications Service (ACS, the California version of the F.C.C. -defined Radio Amateur Civil Emergency Service, RACES) and provision of communications as a public service at many local events such as foot and bike races.

In the 1980s the Club added "amateur" to its legal name (perhaps to avoid confusion with abusive Citizens' Band practices). The Club has in 2012 reverted to its original name: San Francisco Radio Club. It continues to thrive as an active social and technical society of amateur radio operators. Its website is: http://www.sfarc.org.

A few other clubs and organizations have comparable lineages. Harvard University and the Massachusetts Institute of Technology (MIT) in Massachusetts, and Columbia University in New York, occasionally provided wireless experimentation opportunities to some students in about 1909 and perhaps a year or two earlier. They each have amateur radio clubs to this day claiming these early physics lab experiments as their ancestors. Their callsigns are respectively W1AF for Harvard which was 1YE in 1913 ("Y" for training school and in 1907 Harvard's "Pierce" experimental station is listed at 5 KW[43]), W1MX, initially 1XM for MIT; and W2AAE, initially 2XM for Columbia. (The X callsign were assigned to experimental stations after 1912). Today's Radio Club of America derives from young New York area amateur wireless experimenters *circa* 1907 - '09. It first formalized itself in 1909. The Radio Club of America quickly evolved into the distinguished professional and scientific institution it is today. The Wireless Institute of Australia dates back to March 1910. The Radio Society of Great Britain established itself in 1913, and the American Radio Relay League goes back to 1914. Thus amateur radio nationally and worldwide has enjoyed well over a century of growth and service.

Endnotes

1 See Bartholomew Lee, Wireless Comes of Age on the West Coast, 25 *Antique Wireless Association Review* 241 (2012). Most of the pre-1920 detail in this article

not otherwise cited comes from Wireless Comes of Age, and later detail derives largely from sources otherwise cited herein

2 DeForest Wireless Telegraph Company, San Francisco Station PH log of 1906, reproduced in *Pacific Radio News*, January 1917 (Vol. 1, No. 1).

3 *San Francisco Chronicle*, December 26, 1909, insert: "Youthful Wireless Operators" now on file at the KRE Museum of the California Historical Radio Society in Berkeley, California. This article reads as if it were prepared for use by various newspapers, with local detail as the fill-in.

4 Jane Morgan, *Electronics in the West,* Palo Alto, 1967, at 22, giving a 1907 date, as do archives preserved by James Maxwell, W6CH, now at the California Historical Radio Society. Ray Newby (EZM/SEW) and "Doc" Herrold appear in *Modern Electrics*, Vol. III, No. 5, August 1910 at 275.

5 Jane Morgan, supra, at 23; she attributes the founding of the Club to Henry Dickow.

6 From the Official Program of the Pacific Radio Exposition (San Francisco, 1924). Dickow also designed the WW II U.S. Army intercept station - Two Rock Ranch - in Northern California.

7 Amateur Radio Defense, January 1941, at 43.

8 Official Program Pacific Radio Exposition (1924), looking back at the San Francisco Radio Club.

9 *Pacific Radio News,* January 1917 (Vol. 1, No. 1).

10 Public Law no. 264, An Act To regulate radio communication, approved August 13, 1912, accessible at Thomas H. White's Radio History site http://earlyradiohistory.us/ 1912act.htm; see generally Clinton. B DeSoto, *200 Meters and Down*, ARRL 1936.

11 Photograph Archived and Preserved at the Western Historic Radio Museum, Virginia City, Nevada; This Photograph on the Museum Website is Copyright Henry Rogers, All Rights Reserved, used by permission.

12 The wireless station is preserved at the Western Historic Radio Museum, Virginia City, Nevada; Photograph by and copyright Henry Rogers, All Rights Reserved, used by permission. Sharon and Henry Rogers received the California Historical Radio Society (CHRS) "Doc" Herrold Award for 2001 in connection with their museum. M.H. Dodd wrote to *Modern Electrics* in 1909 from Los Angeles with a long description of his station there and two photographs, all of which were published in *Modern Electrics,* Vol. II, No. 2, May 1909 at 114 -15.

13 See generally Eric P. Wenass, Elmer T. Cunningham and the Tube Tangle, 25 *Antique Wireless Association Review* 185 (2012). See also Lee, Wireless Comes of Age… [note 1 above] at 268 ff.

14 U.S. Department of Commerce, Bureau of Navigation, Radio Service Bulletin, No. 23, November 1, 1916, at 10; these Bulletins tell the story of early radio's development with considerable detail including prosecutions of amateurs operating illegally; they are accessible at http://www.fcc.gov/encyclopedia/radio-service-bulletins-1915-1932, and radio history websites such as Thomas

H. White's outstanding site http://earlyradiohistory.us (excerpts and link at /RSBannoc.htm) and others such as http://www.americanradiohistory.com/Service-Bulletin-Guide.htm.

15 *Modern Electrics*, Vol. III, No. 9, December 1910 at 529 published a letter from Stone and a photograph of his Oakland station. A "Y" license, such as Stone's after 1912, issued for technical purposes or to training schools, and experimental stations naturally enough got an "X" license, according to Thomas H. White's Radio History site www.earlyradiohistory.us at /024.htm, article titled US Special Land Stations.

16 *The Wireless Age*, Vol. 4, February 1917, at 353.

17 From the 1924 Pacific Radio Show Official Program, supra.

18 Executive Orders of April 6, 1917 (2585) and April 30, 1917 (2605A).

19 The Club's corporate number is 16407, by which its articles of incorporation are still available from the California Secretary of State.

20 Radio Service Bulletin, October 1, 1919, No. 30, at page 7; but formally by Executive Order 3228, February 13, 1920, also published in the Radio Service Bulletin.

21 *Pacific Radio News,* August 1920 Vol. II, No. 1 at page 7.

22 *Pacific Radio News,* ibid.

23 Photo of station 6BN and Holliway from John Schneider, Voices out of the Fog, The History of KFRC…at www.bayarearadio.org/ (CHRS – Bay Area Radio Museum) at http://www.bayarearadio.org/ schneider/radio112.shtml .

24 John Schneider, Voices out of the Fog, The History of KFRC… at www.bayarearadio.org/ schneider/kfrc1.shtml (CHRS – Bay Area Radio Museum).

25 *Pacific Radio News,* November 1920, Vol. II, No. 1 at 1, preceded by two full pages of promotion in the September, 1920 issue, page 120 -21.

26 *Pacific Radio News,* February 1921, at 216.

27 From *Pacific Radio News,* October 1921, at 98.

28 Author's collection.

29 Author's collection.

30 Elma G. Farnsworth, Distant Vision, Salt Lake City, 1990 at 195, 203.

31 Radio Act of 1927, Public Law No. 69-632, February 23, 1927, 44 Statutes at Large 1162 and codified 47 USC Chapter 4, provisions since repealed.

32 From the 1924 Pacific Radio Show Official Program, supra.

33 Saved from E-Bay by Paul Merrill, W7IV, and made available to the Club by Ed Silvester, NI6S, and Dave Billeci, WA6UHA.Note. "MU" had been Sydney Fass's early callsign.

34 Drawn for Amateur Radio Defense in 1941by San Francisco artist Les Funston, W6QQU. He drew several othr published ham radio cartoons.

35 Clinton B. DeSoto, *Calling CQ -- Adventures of Short Wave Radio Operators,* New York, 1941 at 17.

36 *Radio Amateur Call Book* Summer, 1932, Vol. 13, No. 2.; CHRS archives.

37 Amateur Radio Defense, January 1941, at 42.

38 Data and information from *QST* in several wartime issues.

39 Whimsical phonetics were common at the time; the identifier of what is now the California Historical Radio Society

amateur radio station, W6CF, was [ol'] "chicken feathers."

40 Herb S. Brier, Amateur Radio (column), *Popular Electronics,* April 1967, accessible at http://www.rfcafe.com/references/ popular-electronics/ world-peace-and-amateur-radio-apr-1967-popular-electronics.htm.

41 ARRL's *QST* noted this public service communications assistance. Club lore recalls considerable controversy about what could appear as an involvement in politics, according to Dave Billeci, WA6UHA.

42 See Bartholomew Lee, 9 -11: Amateur Radio in New York, *Popular Communications,* September 2002.

43 *U.S. Navy, List of Wireless –Telegraph Stations of the World,* Washington, D.C 1907 at 26-27.

About the Author

Bartholomew (Bart) Lee, K6VK, xKV6LEE, WPE2DLT, is a long time member of AWA and a Fellow of the California Historical Radio Society (CHRS), for whom he serves as General Counsel Emeritus and Archivist. He has enjoyed radio and radio-related activities in many parts of the world, most recently in Israel. Radio technology and history have fascinated him since he made his first crystal set with a razor blade and pencil lead more than 50 years ago. He is especially fond of those sets of which it is said: 'Real Radios Glow in the Dark.' Bart is a published author on legal subjects and most recently on the history of radio. He has written about and lectured on early radio technology, radio intelligence activities ('episodes in the ether wars') from 1901 into the latter 20th Century, wireless telegraphy especially Marconi's early work, wireless developments on the West Coast since 1899, radio ephemera including radio stamps, and radio in emergency and disaster response. Since 1989 he has made some 20 presentations to the AWA conferences on his research interests including short wave radio and the development of television in San Francisco in the 1920s. The AWA presented its Houck Award for documentation to him in 2003 and CHRS made its 1991 'Doc' Herrold Award to him in connection with his work for the Perham Foundation Electronics Museum. In 2001, during disaster recovery operations in New York after the '9/11' terrorist enormity, he served as the Red Cross deputy communications

lead from September 12 to September 21, (the 'night shift trick chief'). He has served in RACES as the Liaison Officer for the San Francisco Auxiliary Communications System, and as an ARRL ARES Emergency Coordinator. He presently serves as an ARRL Government Liaison and Volunteer Counsel. Bart has been a litigator by trade, prosecuting and defending civil cases in both state and federal court for 40 years. He also had taught Law & Economics for 20 years, including the economic history of telecommunications. He is a graduate of St. John's College (the 'Great Books School') and the University of Chicago Law School. Bart's son Christoffer Lee is also a licensed amateur radio operator and is now also a practicing lawyer. Bart invites correspondence at: KV6LEE@gmail.com .

Bart Lee. Photo by Paula Carmody taken in Indonesia; copyright Bart Lee 2009.

RCA TV Development: 1929 - 1949

©2013 Richard Brewster

ABSTRACT

The Radio Corporation of America, under the direction of David Sarnoff, took the idea of television and brought it to a place where it could become a useful medium of communication and entertainment. This required a considerable financial investment at a time when funds were not available for a questionable return. And, in fact, RCA did not recoup its investment till well after World War Two! Engineers began their work when TV was but a mechanical plaything. New imaging and amplification methods were required. Special vacuum tubes, had to be designed and constructed. The television studio, too, was a new idea to be created. TV receiver design proceeded along with the cameras. As the image standards (a moving target) were upgraded, new cameras had to be invented. This, of course, required a more advanced receiver to reproduce the image. Synchronizing proved to be a challenge as well. Details and images for this paper have been collected from many sources and clearly show how RCA succeeded in bringing to the public the amazing system of television.

While there were others working on electronic TV, RCA's David Sarnoff determined to produce a working system with the help of his former countryman, Vladimir Kosma Zworykin. Sarnoff had taken an interest in Zworykin's work at Westinghouse in 1929, and had begun funding his work there. (1) Westinghouse had little interest in the enterprise.

GENERAL ELECTRIC

Meanwhile, just a few hundred miles away in Schenectady on September 11th of the previous year, General Electric engineers, directed by E. F Alexanderson, managed to broadcast the world's first television play, *The Queen's Messenger* to a handful of viewers. The *Washington Post* reported, on September 21st, that it was received as far away as Los Angeles. The mechanical scanning system employed three projectors, each equipped with a 1000-watt lamp directed against a rotating spiral-holed disc. A lens trained the resultant pattern of 24 lines of light on the actors. Reflected spots of light were picked up

by a pair of photocell-amplifier units and converted to an electrical video signal. The room was dark except for the light from the scanning unit. Fig.1 Special makeup was developed to best reproduce the faces of the actors. Fig.2

The monitor unit, which came to be known as the 'octagon set', displayed a red and black image by means of a similar rotating spiral-holed disc, set in front of a neon lamp. The motor speed was synchronized to that of the transmitter disc; while the neon lamp flashed in accordance with the light impulses picked up by the photocells.

Fig. 1. The Queen's Messenger. (*Radio News*, Dec. 1928)

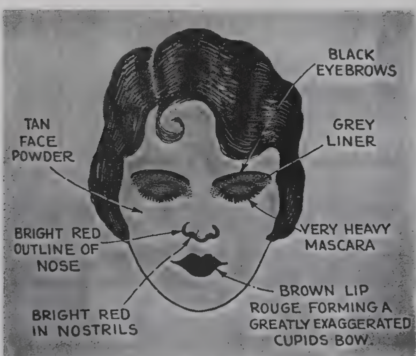


Fig. 2. Makeup for The Queen's Messenger. (*TV News*, Sept. 1931)

A lens increased the 24-line, 20-frame-per-second image size to three inches square. The electronics were built into a late 20's floor-model radio cabinet. (2) Fig.3

This historic broadcast demonstrated that although TV entertainment was possible, it was only minimally effective. The televised area was no more than a foot square and the scanner projected a concentrated beam of light at a specific distance. These factors meant that the actor had to limit his movements to remain on-screen and provide a sharp image. If he turned his head or moved it too far, he would be out of focus or out of the picture. In addition, the flickering light of the scanning beam distracted the actors and even caused headaches.

Fig. 3. GE 'octagon' receiver. (Jack Davis collection)

WESTINGHOUSE

Meanwhile, back at Westinghouse, KDKA, under the direction of radio pioneer, Frank Conrad, was also broadcasting pictures with a similar mechanical camera. But Zworykin, eager to develop an all-electronic television system, had been working to improve his iconoscope since the early 20's. Now, Sarnoff, in an arrangement with Westinghouse, began funding Zworykin's development of the iconoscope as well as his receiving tube – the kinescope.

The 7" by 20" tube, fabricated by *Corning Glass* was given a willemite phosphor screen prepared by Zworykin's group. External vertical deflection plates as well as horizontal deflection coils were employed for scanning. Second anode voltage was 3000. The set was first demonstrated in the lab in May of 1929, and radio transmission, using separate channels for video and sync, was effected in August of that year. Seven of these sets were built. (3) Fig. 4

RCA TAKES OVER

In early 1929, Zworykin famously told Sarnoff that he hoped that in two years and at cost of $100,000, he could produce a workable TV system. Sarnoff replied, "All right, it's worth it." (4) Finally, in 1930, Zworykin's group moved to the RCA labs in Camden, NJ together with some of the GE engineers who were responsible for the 1928 *Queen's Messenger* broadcast. (5) Now, work could begin in earnest.

Meanwhile RCA engineers, also recruited from GE and enamored with their mechanical system, had

Fig. 4. Zworykin's early CRT set. (*Zworykin, Pioneer of Television*)

Fig. 5. Felix on mechanical TV. (*Television, The First 50 Years*)

Fig. 6 RCA 60-line mechanical receiver. (Courtesy Early Television Foundation)

Fig. 7 Received image of Felix. (*The Great Television Race*)

constructed by the summer of 1929, a 60-line, 20-frame per second mechanical scanning camera. They were transmitting images of Felix-the-Cat using RCA's FCC authorized call, W2XBS. (6) Fig. 5. During 1930, the Camden group built several 60-line mechanical receivers to further evaluate the mechanical system. Fig.6. Felix was seen as a red and black image with the disc curvature being quite apparent. Fig.7.

Retired RCA engineer, John Paul Smith explained that, "We gave a demonstration for General Sarnoff of the status of television receivers at that time."(7) A demonstration was arranged with Zworykin's Westinghouse 'lab' set, a mirror-in-the-lid set, the RCA 60-line mechanical set, and the GE 'Queen's Messenger image monitor. Fig.8

Fig. 8 TV set demonstration for Sarnoff. (John Paul Smith collection)

It is obvious that Sarnoff needed this demonstration to determine whether all-electronic TV was the way to go. Since the pickup tube had not yet been 'perfected', he could not be sure when that would happen, regardless of what Zworykin had promised him. In any event, Sarnoff certainly must

have agreed to finance an additional mechanical TV project.

Three sets of a new 60-line mechanical camera system, this time employing eight photocells in order to provide greater sensitivity, were subsequently built in the RCA Camden Development Lab on the 6th floor of building two. The associated electronics racks were constructed by J. M. Morgan and J.P. Smith. According to Smith, the scanning and PJ-19 photocell pickup assemblies were built by M. Trainer and J. Briggs. Fig.9. One of these sets was provided (sold?) to CBS for their experimental broadcasts. (7) CBS's use of this unit was the subject of my AWA Journal article, The Original Television Girl, Oct. 2004. During a phone interview Natalie Towers explained some of the challenges of being an actress in front of a whirling disc – flashing light mechanical TV camera. She noted that both picture and sound were transmitted and that, "…I stood on some kind of platform; it was a high platform. It was all dark in there. It was hard for me to see…to see what I was doing. I heard from my fans – I had fans – and that they said that the reception…there were only about 100 receiving sets in the metropolitan area and they said that the reception was best 100 miles out at sea! That's what they told me… There were two [technicians operating the system]. And they didn't help me; they took a picture of what I was doing. They were very nice young men and after the show they would walk me home…"

When asked whether there she could see a monitor screen, she said, "No. No, I had no idea what I looked like. Fortunately, maybe."

Did you have to wear any special

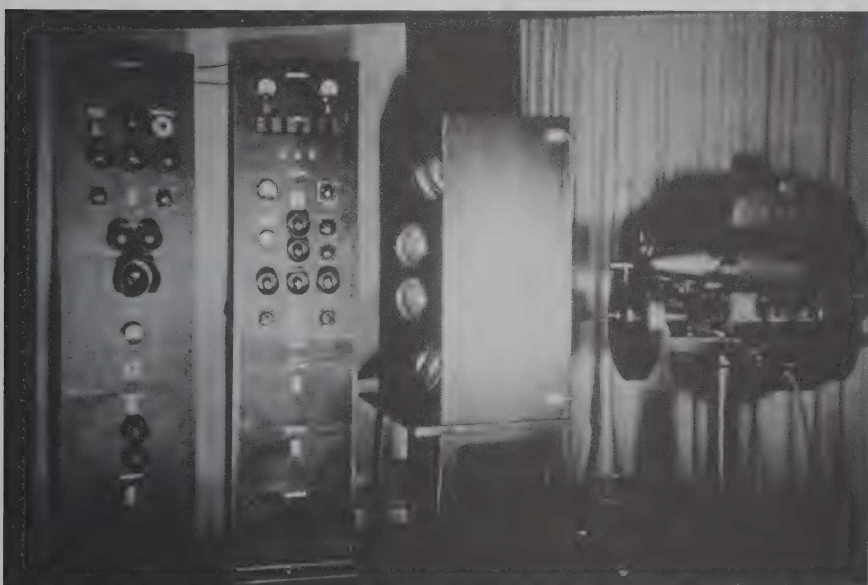


Fig. 9 RCA Camden lab 60-line equipment. (John Paul Smith collection)

makeup? "Yes, very definitely. It was gruesome. I had to have green lips. They put green on my lips." (8)

RCA 1932 TEST SET

In May of 1932, RCA demonstrated their latest TV system using the newly developed 120-line, 24-frame kinescope (Zworykin's name for the CRT) receiver. Picture and sound were tuned separately and the CRT had a green phosphor. (9) In 1984, RCA engineer, Jeff Lendaro discovered an example of this television in an RCA warehouse in Indianapolis. It was being junked and he rescued it. The video receiver is an 11-tube superhet tuning from 35 to 55 MHz. The audio receiver is a 10-tube super, tuning between 55 and 75 MHz. The power unit supplied 1000 and 6000 volts. Fig. 10. The experimental kinescope still has its attached data sheet. (10) Fig. 11.

Fig. 11 120-line CRT. (Jeff Lendaro collection)

Fig. 10 120-line CRT test receiver. (Jeff Lendaro collection)

The 120-line images transmitted to the 1932 test set were produced by giant photocell reflector assemblies, required to pick up as much light as possible from the subject illuminated by the scanning beam. The intense light was

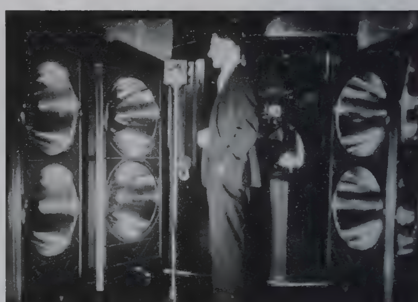


Fig. 12 120-line photocell pickup unit. (John Paul Smith collection)

generated by a 150 amp arc projector and 'chopped' by the 120-hole scanning disc. The resultant image signal was still very noisy according to RCA engineer, Smith, who was also involved the design of this system. It was RCA's final mechanical TV effort. (7) Fig.12.

Mechanical TV technology seemingly had been pushed as far as was possible. It still was a mechanical monster at the transmitter. Although larger pictures were possible by projection, sensitivity at the transmitter end became a greater problem as more lines, meaning less light for the photocells, were added to the picture, as Smith noted. And it still had the same small field and depth of focus problems.

Not surprisingly, RCA engineer G.L. Beers believed, concerning TV viewing at that time, "In the case of usual sound broadcast program, the listener can obtain some measure of enjoyment while reading or engaged in some other diversion. To derive any degree of pleasure from a television program requires the entire attention of the observer." (11) *Television*, RCA, volume 1, pg. 201.

ELECTRONIC CAMERA DEMONSTRATED

In February of 1933, a TV demonstration finally incorporated an electronic camera equipped with Zworykin's recently developed spherical iconoscope. (12) An inside view of this camera reveals a top-mounted mirror which reflected the image on the mosaic to the operator. Three tubes provided two stages of video gain as well as blanking

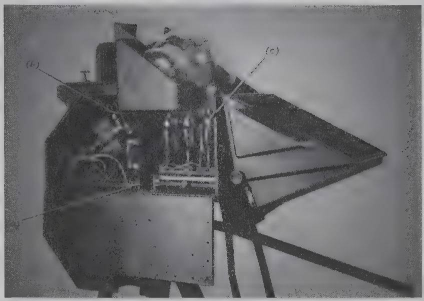


Fig. 13. 1933 iconoscope camera. (*Television*, Vol. I)

amplification. Fig.13. Smith explained that for signal transmission, they developed a crude coaxial cable consisting of a 4 mil copper-plated steel wire threaded through rubber tubing. (7)

A simplified explanation of iconoscope operation is as follows: An image focused on the photosensitive mosaic globules liberates electrons leaving them positively charged in 'bright' areas. The electron gun produces a scanning beam that additionally charges the globules. This differential charge is capacitively coupled to the signal plate, generating a video signal. The iconoscope had the advantage of storage, that is, the mosaic globules continued to accumulate charge during the scanning process. (13) Fig. 14.

Finally the rotating disc system had been replaced by an electronic tube, insensitive though it was. But, unlike the mechanical system, it could (and would!) be made more sensitive. And since it did not rely on a generated spot of light, it also could be used outside of a studio. It was a big step forward. Interestingly, in the UK, John Logie

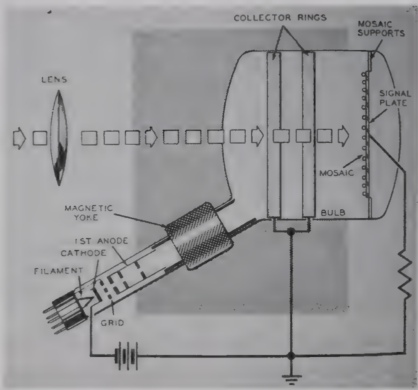


Fig. 14 Iconoscope operation. (*Principles and Practices of Telecasting Operations*)

Baird kept working with his mechanical system well into the late 30's.

Prior to the electronic camera, the mechanical scanning system generated its own sync pulses by providing a signal that could enable the receiver disc motor speed to be locked to that of the transmitting disc. But the electronic camera required sync pulses to direct the scanning beam as well as to provide sync for transmission to the receiver. An opto-mechanical device, consisting of a rotating disc having 243 apertures (for horizontal) and 2 apertures (for vertical) along with photocell assemblies, did just that. Fig. 15.

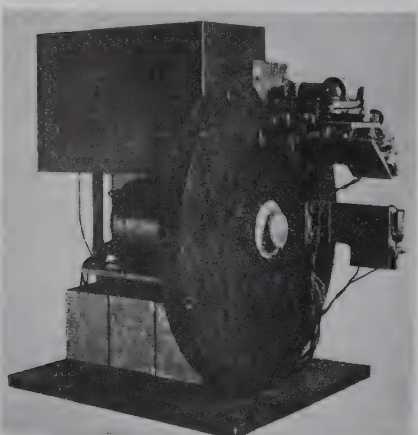


Fig. 15 Mechanical sync generator. (*Television*, Vol. I)

For the February 1933 television demonstration, a newly-developed test receiver reproduced a 243-line, interlaced, 60-frame picture, although officially, RCA claimed only 240 non-interlaced lines. Interlacing involves transmitting odd lines of a picture and then the even lines, while eliminating noticeable flicker and requiring less bandwidth than transmitting all the lines at once. It was a big advance in TV technology. Sound and video were now on the same carrier and thus could be tuned by one control.

The RF circuit incorporated one local oscillator feeding two mixers and their respective IF strips. The sound channel had 3 IF stages with AGC, while the video had 5 IF stages, also with its own AGC. The sync and deflection circuits had 9 tubes driving a vertical deflection yoke and horizontal deflection plates. Second anode voltage was 4600. The exotic power transformer had 6 filament as well as high and low voltage windings. Tube complement, including 4 rectifiers, was 33 plus the 9-inch, vertically mounted green-screen kinescope. Fig. 16.

[An explanation of the CRT vertical mounting is in order here. Zworykin first used this arrangement in 1929 and RCA engineers continued it into the 1940's. Firstly, the early tubes were long, partially because the electron gun was

rather complex, incorporating deflection plates for electrostatic horizontal deflection. Vertical deflection was magnetic, necessitating a deflection coil that further lengthened the neck of the tube. But the real problem was the limited deflection angle that could be accommodated. Wide deflection angles would require greater horizontal and vertical drive. In addition, style was important. A television receiver had to look much like the console radio of the day and a lift top mirror displaying a reflected image was thought to be the solution. Also, room light reflection on the CRT was considered to be problematic while it was believed that the mirror provided a wider audience view. (14)]

In a makeshift studio, the 1933 demonstration included the televising of Mrs. Ruth Trainer, who sang a selection accompanied at the piano by Mrs. Katherine Bedford. The very insensitive iconoscope pickup tube required intense lighting. In this scene, 17 kilowatts of light were used. Close examination of the photo reveals that a heat-tolerant stand-in kindly replaced Mrs. Trainer during some of the testing. Fig. 17. The received image had a green tint. Fig. 18.

Never the less, this had to be a big

Fig. 16 243-line set, RC 58. (RCA, TR-208c)

Fig. 17 Mrs. Ruth Trainer on camera. (RCA, TR-208c)

Fig. 18 Received image of Mrs. Trainer. (RCA, TR-208c)

deal for David Sarnoff. He was finally getting the TV system which Zworykin had promised him four years earlier. And yet we know that it was by no means ready for public presentation. That was another six years (and a great deal more money) in the future.

INEXPENSIVE TV

During the summer of 1934, a five-inch direct-view TV was developed by the Research Division of RCA to demonstrate that a relatively inexpensive consumer television receiver could be produced. (15) It displayed a five-inch direct-viewed picture with a line resolution which, by then had been raised to 343. Newly available type 53 dual-triodes, as well as fewer IF stages, reduced tube count to 19, less than that of some radios of that time. The use of a five-inch CRT allowed a less expensive, relatively low 2300-volt second anode power supply. AGC and a newly-developed automatic background control were part of the circuitry. Horizontal deflection plates were eliminated, reducing CRT complexity and cost. Sub-assemblies for various functions were employed which could be built and tested individually.

The lab report did not mention estimated selling price but did indicate that the receiver had operated for over 700 hours of actual use. This set was apparently never publicly demonstrated and the report on its development was stamped Confidential. Fig. 19.

One must conclude that RCA would liked to have marketed this set, but obviously it was decided that the camera was not up to the challenges that commercial broadcasting would demand. And a real studio was still needed. But within the year, Sarnoff would take action to rectify that situation.

Fig. 19 Low cost 343-line receiver, RR 74, (RCA, TR-244-C)

1936 TV DEMONSTRATION

In May of 1935, RCA President Sarnoff announced to stockholders, that a million dollars (big money during the depression) would be allocated for the development of a TV system which would include the construction of studio facilities as well as a new transmitter and antenna atop the Empire State Building. In mid-1936 testing began in New York City's Radio City studio 3H. (16)

The new twin-lens camera provided a lens for the iconoscope and allowed

the operator to view, through a duplicate lens, a bright, inverted image on a ground glass. The previous camera gave the operator a dim image reflected from the iconoscope mosaic. Fig. 20. An open view of the camera shows the new cylindrical Ike. Fig. 21. It still required intense lighting (1000 to 2000 foot-candles) and was the industry standard camera well into the '40s, when the

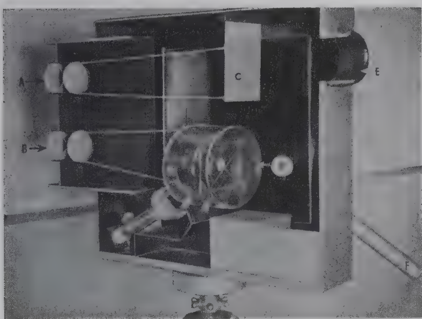


Fig. 20 1936 iconoscope camera optics. (*Television*, 1939)

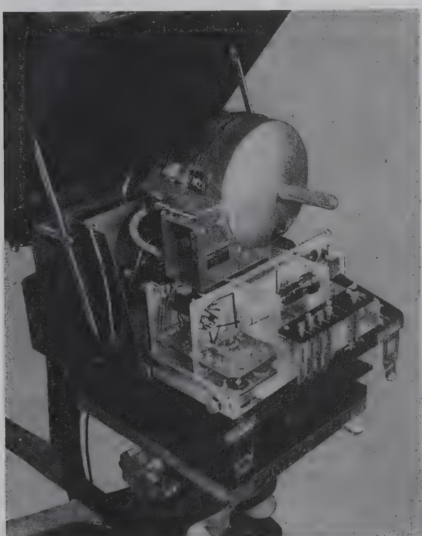


Fig. 21 Iconoscope camera internal view. (Zworykin, Morton *Television*, 1940)

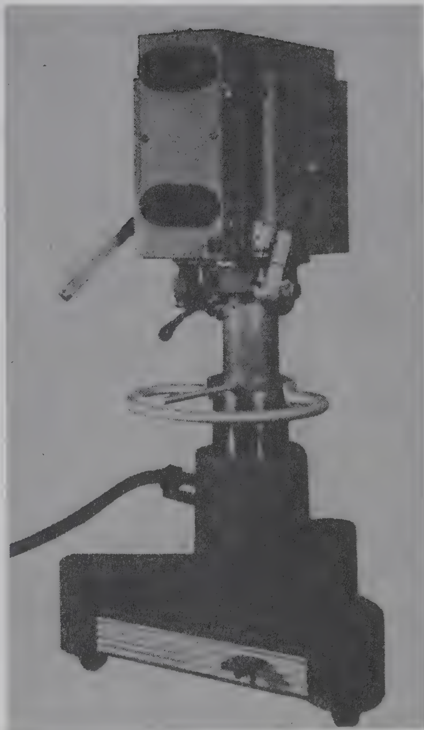


Fig. 22 Iconoscope camera system. (Zworykin, Morton *Television*, 1940)

highly-sensitive image orthicon became available. Fig. 22.

The Radio City studio was big: 50 by 30 feet and 18 feet high. Three cameras were available for use, with 6.5, 14, and 18-inch lenses. Since the studio was air conditioned, up to fifty kilowatts of lighting could be used, supplied by DC generators. (17) Fig. 23. In addition, RCA engineers designed and equipped the control room overlooking the 3H studio. Fig. 24.

Duplicate, redundant sync generators (which had, by now, replaced the mechanical unit) were continually energized to insure stability. Each consisted

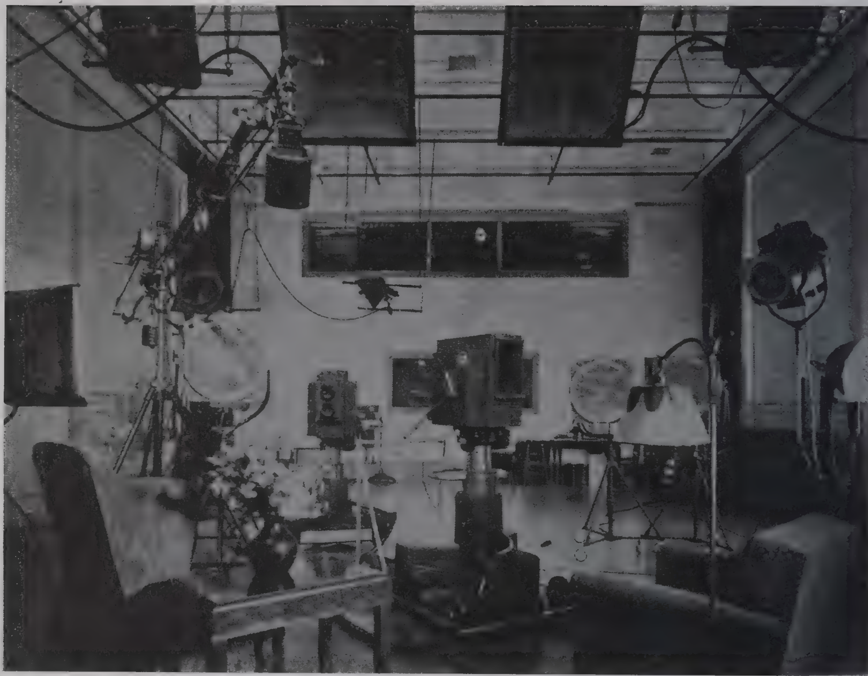


Fig. 23 1936 Radio City studio 3H. (*RCA Review*, Vol. I, #4)

Fig. 24 1936 control room. (*Electronics*, Jan. 1937)

of a 20,580 cps oscillator, locked to the 60-cycle line driving 'stair-step' counter frequency dividers incorporating the recently- developed type 79 dual-triode. (18) Fig. 25.

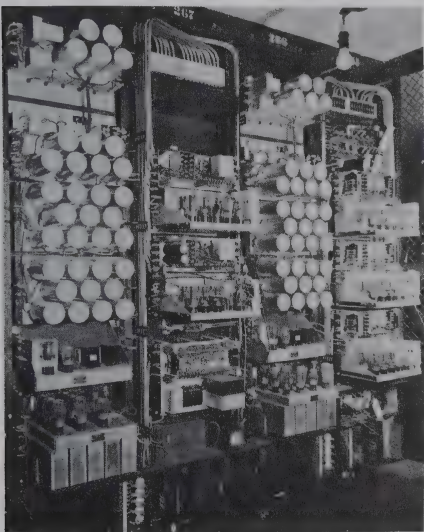


Fig. 25 Electronic sync generator. (John Paul Smith collection)

Fig. 26 Makeup for 1936 test. (*Radio Craft*, Aug. 1937)

TV during the 1936-1937 season, experimental work still required unusual makeup as can be seen in Fig. 26.

The RR-359 receiver, originally with a nine-inch screen, was designed for use in the 1936 343-line tests. This 32-tube set, plus CRT, used older 6D6's, some octal types, as well as experimental tubes. Separate video and audio IF amplifier strips were employed. The picture was still green and black. (19) Fig. 27.

A rear view of the RR-359 shows the unusual IF amplifier tube mounting method designed to reduce the lead length between stages. Similar to earlier designs, this set had a power supply with two low voltage and two high voltage rectifiers. The sound channel had a pair of 2A3's for audio output as well as bass and treble controls. Also featured were coarse and fine vertical and horizontal hold controls suggesting the future move to 441 lines. Fig. 28.

The RR-359 RCA official promotional photo reads, "This picture shows you how the National Broadcasting Company's experimental television is being received in the homes of a small group of engineers. The receiver set – which is in a state as experimental as television programs – is about the size of a console radio."

On November 12, 1936 broadcast station executives from around the country were invited to see a demonstration of RCA's newest TV system. Almost 300 viewed programming on RR-359 sets on the 60th floor of the RCA building. Transmissions were

Fig. 27 1936 test receiver, RR 359. (Nat Pendleton Collection)

relayed from the one-mile distant Empire State Building. Luncheon was served in the Café François, Rockefeller Center. (20) Fig. 29.

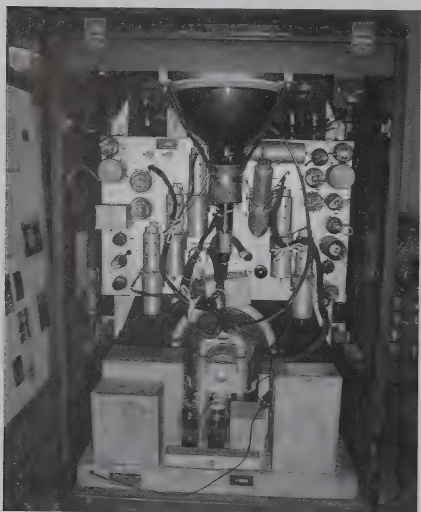


Fig. 28 RR 359 rear view. (Nat Pendleton Collection)

Now, it would appear, RCA could go on the air. They had everything needed. Why did Sarnoff delay for several more years? Was it the depression? In fact, BBC in the UK began to broadcast during this time frame with a slightly more detailed 405-line picture. And they kept this 405-line system going for many decades; even after color broadcasting began on a separate band.

MOBILE TV VAN SYSTEM

On December 12, 1937, a mobile system, consisting two 26-foot busses was delivered by RCA, to NBC in New York City. One motor van provided two portable single-lens iconoscope cameras and their support equipment. The second van contained the177 MHz transmitter with antenna which could relay a remote pickup to the Empire State Building. (21) Fig. 30. Then on September 15, 1938, NBC conducted the first sidewalk interview with passers-by in Rockefeller Plaza. (22)

Now, NBC (RCA) was demonstrating the kind of programming which we have come to expect from television. And this surely was calculated to raise the public awareness of this new communications and entertainment medium.

TV PRESENTED TO THE PUBLIC

David Sarnoff unveiled RCA's 441-line television system to the public at the New York World's Fair in April of 1939, having by this time, spent 10 million dollars for it's development. Never the less, it was still experimental, hav-

Fig. 29 November 1936 demonstration. (*His Majesties Voice in America*)

Fig. 30 Mobile TV van system, 1937. (*His Majesties Voice in America*)

Fig. 31 Sarnoff at the 1939 NY World's Fair. (*His Majesties Voice in America*)

ing not been given the go-ahead by the FCC. (23) Fig. 31.

Anticipating the World's Fair presentation, RCA had been busy

Fig. 32 TRK-12 promotional photo. (RCA photo)

developing a series of four TV receivers to tempt the public. The top-of-the-line TRK-12, a 12-inch, $600 television receiver was the big draw at the Fair. A 1939 RCA publicity photo depicts this mirror-in-the-lid TV in an upscale home setting. It tuned channels 1 - 5, 44 to 90 MHz. Finally the picture was black and white. Fig. 32. Tube complement: 23 including the 12AP4 picture tube. In addition, the audio amplifier, for AM sound, was included as part of a separate multi-band radio receiver. RCA also offered the TRK-9 and TRK-5, nine-inch and five-inch direct-view TV receivers.

The TRK-12 was (and is) quite an

excellent set. Although it was designed for a 441-line system, it was easily converted to work with the 525-line standard soon to follow. The set was obviously intended for a strong signal location, since there was no RF amplifier in the antenna circuit. Interestingly, on a visit to Franklin Roosevelt's Hyde Park, I spotted a TRK-12. That's more than 70 miles from the Empire State Building. Maybe RCA added an RF amplifier. I didn't get a chance to examine the set. I'll have go there again sometime. Some time ago, I restored one and was able to reliably watch modern TV shows.

RCA also offered the table-model TT-5 for only $200, but it required a separate radio connection to provide the sound amplifier and speaker. Thus, the set was often pictured with a console radio nearby. Fig.33. In fact, late 30's RCA radios often were advertised as ready for use as an adjunct to a future TV. This would hopefully encourage folks to purchase an RCA radio rather than to wait for TV.

RCA designed everything needed for its new system of television, even

Fig. 33 TT-5 promotional photo. (RCA photo)

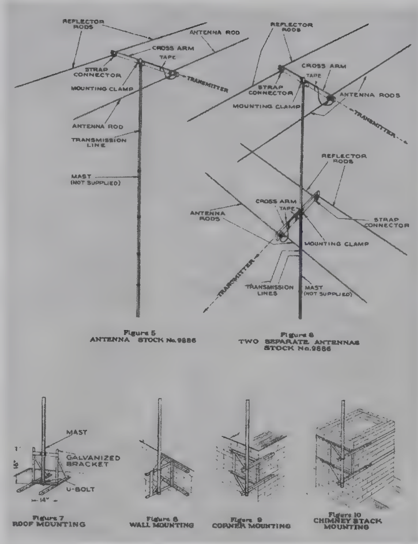


Fig. 34 RCA home TV antenna. (RCA sales brochure)

receiving antennas. Interestingly, a second antenna is recommended in order to receive an additional channel from another direction. Fig. 34.

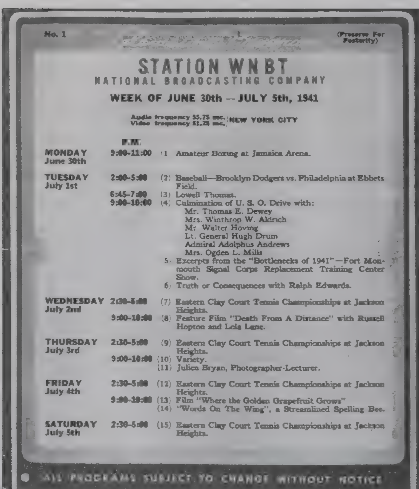
BROADCASTING

During the year from first the initial World's Fair telecast, NBC broadcast, with virtually no sponsorship, 601 hours of programming, including over 60 dramatic productions and numerous sporting events. In March of 1940, scenes from an opera were telecast from the NBC studio. Fig.35. Test patterns were on the air for an additional 800 hours. It was estimated that there were about 3000 TV sets in use in the NY City area in April of 1940. (24)

During this period, required TV makeup consisted of; Lips: indian red-brown, Complexion: ranging

Fig. 35 March 1940 opera broadcast. (Marschall, *History of Television*)

from burnt-orange to peach-tan, eyes: outlined in brown. (25)



No. 1 (Preserve For Posterity)

STATION WNBT
NATIONAL BROADCASTING COMPANY

WEEK OF JUNE 30th — JULY 5th, 1941

Audio frequency 55.75 mc. / Video frequency 51.25 mc. NEW YORK CITY

	P.M.		
MONDAY June 30th	9:00-11:00	(1)	Amateur Boxing at Jamaica Arena.
TUESDAY July 1st	2:00-5:00	(2)	Baseball—Brooklyn Dodgers vs. Philadelphia at Ebbets Field.
	6:45-7:00	(3)	Lowell Thomas.
	9:00-10:00	(4)	Culmination of U. S. O. Drive with: Mr. Thomas E. Dewey, Mrs. Winthrop W. Aldrich, Mr. Walter Hoving, Lt. General Hugh Drum, Admiral Adolphus Andrews, Mrs. Ogden L. Mills
		(5)	Excerpts from the "Bottlenecks of 1941"—Fort Monmouth Signal Corps Replacement Training Center Show.
		(6)	Truth or Consequences with Ralph Edwards.
WEDNESDAY July 2nd	2:30-5:00	(7)	Eastern Clay Court Tennis Championships at Jackson Heights.
	9:00-10:00	(8)	Feature Film "Death From A Distance" with Russell Hopton and Lola Lane.
THURSDAY July 3rd	2:30-5:00	(9)	Eastern Clay Court Tennis Championships at Jackson Heights.
	9:00-10:00	(10)	Variety.
		(11)	Julien Bryan, Photographer-Lecturer.
FRIDAY July 4th	2:30-5:00	(12)	Eastern Clay Court Tennis Championships at Jackson Heights.
	9:00-10:00	(13)	Film "Where the Golden Grapefruit Grows"
		(14)	"Words On The Wing", a Streamlined Spelling Bee.
SATURDAY July 5th	2:30-5:00	(15)	Eastern Clay Court Tennis Championships at Jackson Heights.

ALL PROGRAMS SUBJECT TO CHANGE WITHOUT NOTICE

Fig. 36 NBC program schedule, week of June 30, 1941. (Jeff Landaro collection)

In May of 1941, the FCC officially raised the line rate from 441 to 525. (26) Finally, in June of 1941, commercial TV was given the go-ahead by the FCC. Twenty-one stations went on the air, including WNBT (NBC) in New York City. (27) That station provided a weekly schedule to all TV owners in the viewing area who were then requested to give written opinions of shows watched. Most programming was for a couple hours in the afternoon and between 9 and 10 in the evening. Fig. 36.

With the coming of WWII, although a few shows continued to be broadcast, television was sidelined until 1946. In fact, in May of 1942, the FCC limited New York stations NBC and CBS to a maximum of four hours of TV broadcasting a week. (28)

Fig. 37 1945 RCA TV camera. (*Televisor*, Nov. 1945)

An advertisement in the Nov.-Dec. 1945 issue of The *Televisor* shows one of the many systems that RCA would be making available to TV stations which would be coming on the air in the years after WWII. The basic twin-lens 1936 iconoscope camera was still in use at that time. Fig. 37.

THE IMAGE ORTHICON

A giant improvement was made when the image orthicon was first publicly demonstrated in October 1945 and used for TV pickup at the Army-Navy football game later that year. (29) This device is about 100 times more sensitive than the iconoscope. The image multiplier section of the tube provides a gain of 5. The signal multiplier at the tube base, utilizing a series of secondary emission rings, increases that by a factor of 20. Fig. 38. (30) According to my 1952 *Allied Radio Catalog*, this exotic tube cost nearly as much as a new car at that time.

The IO camera was typically equipped with a lens turret having lenses ranging from 35 mm to 13 inch. Optical focusing was accomplished by a knob on the side of the camera which moved the pickup tube assembly

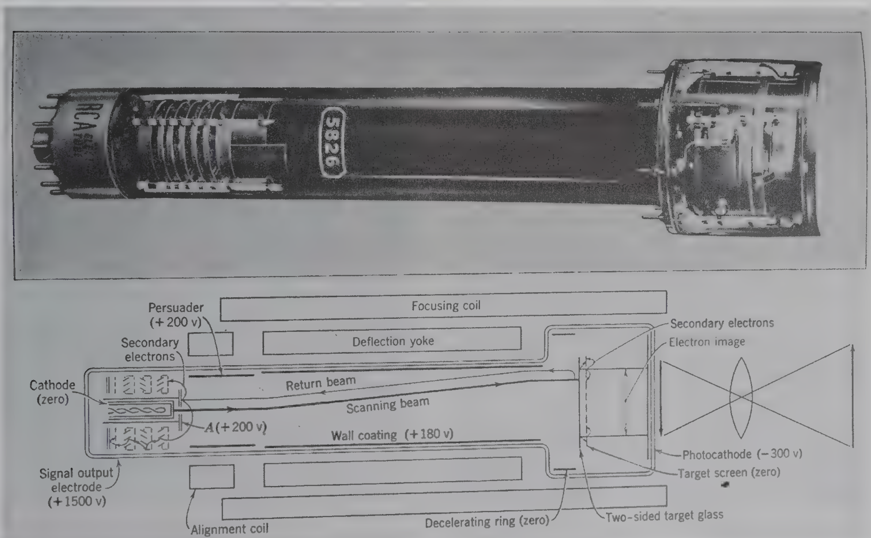


Fig. 38 Image Orthicon. (Zworykin, Morton, *Television*, 1954)

Fig. 39 TK-10 camera. (*Television Equipment Theory and Operation,* 1949)

with respect to the lens. The operator was provided with a headset which fed program sound to one ear and studio direction in the other. (31) And finally the operator had a CRT view-finder for more effective use under all conditions. This first IO camera, the TK-10 incorporating a type 5655 image orthicon, became available in late 1947. Fig.39.

THE 630TS

On September 17th, 1946, RCA introduced the 'Model T' of television receivers. RCA Service Data-1946 No. T1 explains: "Model 630TS is a thirty-tube, direct-viewing, 10" table model Television Receiver. The receiver is complete in one unit and is operated by the use of seven front-panel controls. Features of the receiver include: Full thirteen channel coverage; F-M sound system; Improved picture brilliance; A-F-C horizontal hold; Stabilized vertical hold; Two stages of video amplification; Noise saturation circuits; Three stage sync separator and clipper; Four mc. band width for picture channel, and reduced hazard high voltage supply." Although it was not mentioned, the 630TS did have an excellent range-increasing RF amplifier. The set cost $375, more than a typical months' pay for many folks. (32) Many manufactures paid royalties to RCA to put their name on similarly designed television receivers. In spite of the price, these sets were immensely popular. Although, designed for a 10-inch picture tube, the '630' was easily upgraded to accommodate a much larger image tube, keeping it popular into the early 50s.

About 1947, I remember watching Texaco Star Theater, along with half of my suburban NY neighborhood, on one of these 10-inch sets. It never occurred to us that the picture was too small to provide adequate entertainment value. Fig. 40.

Fig. 40 630TS 10-inch television receiver. (author's collection)

COLOR TELEVISION

RCA's prototype fully-electronic color camera employed special tinted semi-transparent mirrors to separate the image into red, green, and blue components, each color scanned by its own image orthicon. Fig. 41.

At the receiving set, the three primary color signals are recombined in the tri-color picture tube. On October 10th, 1949, RCA demonstrated to the FCC their all-electronic, compatible color system. (Compatible meant that the color signal could be received on a black and white set, although not in color.) That same day, the TV show, Kukla, Fran and Ollie, became the first regular television program to be seen simultaneously in color and black-and-white. (33) The first shadow-mask tri-color tube was demonstrated in the lab in the fall of 1949. (34) Fig.42 depicts one of the earliest color test images.

Fig. 41 Prototype color camera. (*Images of America, DS Research Center*)

Fig. 42 Experimental received color image. (Zworykin, Morton *Television*, 1954)

Meanwhile CBS had developed a mechanical color system that produced great pictures. But it was not 'compatible' and it was another motor-driven spinning disc system. Never the less, the FCC authorized its use anyway, since that they believed that RCA's electronic system, still in the developmental stage, would not be acceptable. The FCC later reversed its position and authorized the RCA system.

CONCLUSION

RCA having invested 50 million dollars and two decades of effort was finally able to make money on TV by 1949. They owned most of the patents and had the cameras, studio equipment, transmitters and receivers; all sought

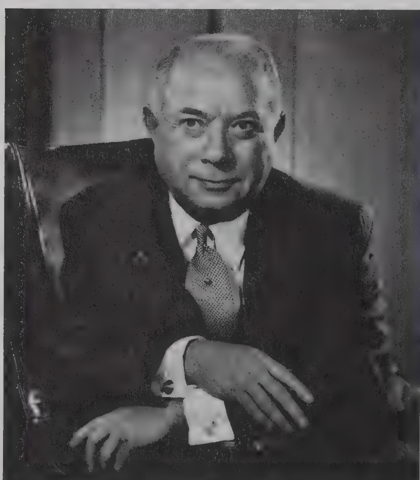


Fig. 43 David Sarnoff. (Lyons, *David Sarnoff*)

after by eager TV stations and viewers alike. David Sarnoff's multi-million dollar gamble finally paid off. Fig. 43.

During the past couple centuries; we have seen many inventions, invariably the product of one person's efforts. For example, radio communication developed as a result of a number of lesser inventions. In the twenties, putting a radio station on the air was not a difficult proposition; in fact, there were hundreds. Radio receivers were often cheap and simple; many folks built their own, sometimes just a simple crystal set.

Television, on the other hand, was a much greater challenge, since it required the production of an exceedingly complex system. The TV receiver was far more elaborate than a radio. As a result, the development of TV required the combined efforts of many technicians supported by an industrial complex and directed by someone who had a *VISION.*

REFERENCES

1. Eugene Lyons, *David Sarnoff*, 1966, pg. 209.
2. *Radio News*, "Television Makes the Radio Drama Possible, December, 1928, pg.524
   Television News, How we staged the World's First Television Play, October, 1931, pg.260.
3. V.K. Zworykin, "Television with Cathode Ray Tube for Receiver". *Westinghouse Scientific Paper* #393A, 10-21-29.
4. Eugene Lyons, *David Sarnoff*, 1966, pg. 209.
5. W. Rupert Maclaurin, Invention and Innovation in the Radio Industry, *MIT*, 1949, pg. 204.
6. *Radio News*, June, 1929.
7. John Paul Smith, RCA engineer, interview, June 1989.
8. Natalie Towers, CBS actress, interviews, July 10, 2004, Feb. 26, 2005.
9. RCA Institutes Technical Press, Television, Vol. 1, pg. 187.
10. Jeff Lendaro, The 1932 Field Test Receiver, Radio Age, Apr. 1995
11. G. Beers, Television, RCA, Vol. I, pg. 201.
12. RCA Lab Report TR-208C, 5-24-33.
13. Television Equipment Theory and Operation, RCA, May 1949, pg. 3-39.
14. Zworykin Morton, Television, 1940, pg. 590.
15. RCA Lab Report TR-244, dated 10-9-34.
16. Broadcast News, Dec. 1936, pg. 2.
    O. B. Hanson, RCA Review, Apr. 1937.
17. Zworykin, Morton, Television, pg. 571.
18. John Paul Smith, RCA engineer, interview, June 1989.
19. RCA WW-303120, RR-359 schematic, March 1937.
20. Broadcast News, Dec. 1936, pg. 5.
21. Zworykin Morton, Television, 1940, pg. 617.
22. Television's First Year, NBC, 1940.
23. Eugene Lyons, David Sarnoff, 1966, pg. 209.
24. Television's First Year, NBC, 1940.
25. America's First Television Tour, NBC, 1939.
26. Television Report, Order, Rules, and Standards, FCC, May 3, 1941.
27. Orrin E. Dunlap, Jr, Dunlap's Radio and Television Almanac, 1951, pg. 136.
28. Ibid.
29. Dunlap, pg. 160, 161.

30. Zworykin, Morton, Television, 1954, pg. 366.
31. Television Equipment Theory and Operation, RCA, 1949.
32. Frederick O. Barnum III, His Majesties Voice in America, 1991, pg. 233.
33. Dunlap, pg. 187.
34. Alexander B Magoun, Images of America, David Sarnoff Research Center, 2003, pg. 46..

RCA Lab Reports courtesy of The Hagley Museum and Library, Wilmington, DE.

ABOUT THE AUTHOR

Richard Brewster was born in 1938 and grew up on Long Island, NY. As a child, old radios and even an occasional discarded TV, objects of extreme interest to him, were summarily reduced to their bits. Electronics magazines were devoured along with traditional comic books. And since this was before *Popular Electronics,* much of the material was beyond the ten-year-old. Several construction projects resulted in failure although he was finally successful with a *Heathkit* phonograph. TV interest began when his brothers discovered a pre-war set in an abandoned warehouse a mile from his home. He turned it into an oscilloscope, completely unmindful of the lethal 4000-volt second anode supply.

A 1960 graduate of Worcester Polytechnic Institute, Richard received a degree in Electrical Engineering, specifically communications. His first job was designing a multi-band submarine radio direction finder back when nuvistors and transistors were fighting it out for supremacy. Later positions involved working for the Air Force and then for the Navy on specialized communications and navigation equipment. Finally, he settled into a long-term position with Westinghouse as designer of nuclear electrical and control systems. Additionally, he supervised construction and startup at a number of Nuclear Power Stations in the USA and overseas.

Spending time at Westinghouse's Pittsburgh headquarters led to involvement with famous radio station KDKA and the founding of the Pittsburgh Antique Radio Society. Here communications history came alive, leading back to his original interest: television. In the late 70's the acquisition of another pre-war TV, this time a 'basket case', became a successful restoration project. Some years later, an RCA TRK-12 was also successfully brought back to life.

Richard retired from Westinghouse in 1995 and almost immediately took over the *AWA Journal* TV column from Jack Davis. Amazingly, he had opportunities to interview significant TV people. He met the fellow who helped design RCA's mechanical scanning equipment and also interviewed the actress who performed before it. Other such opportunities provided input to his quarterly *AWA Journal* TV column articles. A 2012 story on Hollis Baird's TV work led to his receiving the *Bruce Kelly Journal Award.*

A wife, three daughters, and six grandchildren later, he now spends

part of most years in Africa with the NGO, *Mercy Ships*, and, in 2000, held the position of Chief Radio Officer on a 12,000 ton hospital ship. This, without a ham license! Since much equipment on the half-century old ship was vintage, tracking down problems was interesting to say the least. At one point he was able to bring the ship's gyrocompass back to life. Later, while docked in a remote African country, he solved a problem with a neighboring ship's satellite telecommunications system, allowing them to safely sail from port. Most recently, Richard volunteers as surgical photographer for *Smile Train*, the cleft-lip and palate repair group that repairs faces in West Africa.

Richard Brewster

Robert E. Lacault and the invention of the Ultradyne

Abstract

History has remembered the names of the giants in radio development but many of the radio pioneers that made less significant contributions have been lost to time. One of these men is Robert Lacault (Figure 1). When I started my research, I found very little information about Lacault, or his radios. Ed Lyon had written a short piece in the Mid-Atlantic Radio Club Newsletter which explained the operation of the Ultradyne's modulator circuit but did not focus on the inventor. There were also the *Vintage Radio Identification Sketch-Books of D.H. Moore*, and his monograph entitled *The Ultradynes*. These sources and a few schematics in the Rider service manuals were all that I could find. What I have learned is very different from what was documented by D.H. Moore. I am sure that like Moore, I will also come to some wrong conclusions. The purpose of this article is to rekindle interest in Lacault and his radios. During his short 31 year life he was a soldier, engineer, author, editor, inventor, businessman, and husband. He had worked with such greats as General Ferrie, Lucien Levy, and Hugo Gernsback. His writing has been credited with re-fueling interest in television development.

Robert Emile Lacault was born on August 27^{th}, 1897 in the Second District of Paris France. He was the son of Henri Victor Lacault, and Amelie Stephanie Menault Lacault. Robert's father was a trader and it is thought that he was well educated based on samples of his handwriting [1]. Robert's military records show that he was 1.74 meters tall with dark brown hair and dark grey eyes. Records from Ellis Island show his ethnicity as French-Hebrew.

Figure 1. Photograph of Robert E. Lacault from the June 1929 issue of *Radio News. p. 1090*

It is likely that Robert spent his entire childhood living in Paris. No records have been found regarding his education but it is known that he had a good command of the English language at an early age. By 1911, and at the age of 14, he was one of France's earliest amateur radio operators.

Robert had installed an amateur radio station in the family's Paris home which consisted of a receiver using an electrolytic detector, a spark transmitter, and a very large antenna. He enlisted amateurs that he had met on the air to form one of France's earliest radio clubs. Since none of the club members could read English, Robert would translate and read articles to the club from the only radio magazine available to them at that time, *Wireless World*, published by Wireless Press in London. The club would experiment with different circuits from the magazine articles. Years later Robert said that there was very little to be heard over the air. During these early years you would only hear the signals sent via the Eiffel Tower twice a day, and the press messages transmitted at eight o'clock at night [2].

Europe erupted into war and Robert joined the French Army on July 15th, 1915. His records indicate that he was the 128th volunteer to mobilize from the second district of Paris [3]. Robert was assigned an army service number of 8046. He enlisted as a Private (Second Class) and listed his profession as an Electrician-Telegraphist with an address of rue de Turenne No. 31-2nd District Paris. He volunteered for the duration of the war at Angouleme, in the 8th Regiment of Genie, known also as the Signal Corps [4].

There are few details recorded in his military records about his assignments, or work during his military service. What we do know has been pieced together from other sources, including magazine articles, ads, and other records. During the war Lacault was attached to the French Radiotelegrapie Mititaire, and working in the laboratory of the TSF, "Telepraphie Sans Fil" of the Eiffel Tower. At the TSF Laboratory Lacault worked among the famous French Engineers Marius Latour, and Lucien Levy, and this is the period of time that Lacault started working on his modulator circuit, which he would later patent, and incorporate into his Ultradyne superheterodyne receivers [5]. Lacault had worked directly under General Gustave Ferrie, and had written that he had, "worked on the development of the first reflex amplifiers, which were designed for use in the French Army during the war by Mr. M. Latour, the well known engineer". Mr. Latour was one of the principal engineers on the French team that developed the superheterodyne, and this establishes a link between Lacault and this historic effort [6] [7].

Robert would be promoted to Corporal on May 10th, 1918, and released from the army on September 9th, 1919. He would next find employment with the company Paz and Silva, makers of various electrical parts and radio apparatus. During his employment at Paz and Silva he directed the motor and

dynamo departments, and telephone installation [8]. His stay at Paz and Silva was very brief and during the fall of 1920 he set a new course for his life, and found a new home, New York City.

The Gernsback Years

No information has been found as to why Robert moved to New York City. Had he already accepted a job offer, or had he just wanted to visit the city, I doubt we will ever know. What is known is that he sailed from the port of LeHavre, France onboard the *La Lorraine*, arriving in New York on October 11th, 1920 [9]. Ellis Island records show that Robert was 23 years old, single, and shows his ethnicity as French. This differs from Moore's accounts in his *Vintage Radio Identification Sketch-Books*. Moore writes, "The man himself, of Franco-American parentage, had gone to France early on in the Kaiser's War and had become an officer in the French Signal Corps"[10]. Later Ellis Island records from 1923 show Robert's ethnicity as French-Hebrew. This and other inconsistencies were found during my research on Lacault. Robert would find employment quickly as a writer for the magazines *Radio News* and *Science and Invention*, both owned by Hugo Gernsback. The earliest article that I have found accredited to Lacault was published in December 1920, "A Three Tube Combination Radiophone Transmitter and Receiver" [11]. His articles would continue to be seen in *Radio News* until his death in 1929. Lacault wrote mostly radio construction pieces for *Radio News*, but his work in *Science and Invention* sometimes had a different focus. Between January 1922 and August 1923, Robert had eight articles published in *Science and Invention*. The first, "Jazz from the Air," was no more than covering a Hugo Gernsback radio lecture broadcasted from Newark, New Jersey [12]. The April 1923 *Science and Invention* contained the only Lacault article about television, "The Belin Radio-Television Scheme". This article is noted in the book, *Zworykin, pioneer of Television*, for having been a catalyst during the early years of television research. In regards to Lacault's article it states, "This article probably did the most to rekindle interest in television during this period after the war" [13] [14]. Another interesting article to find its way into *Science and Invention* was a joint Hugo Gernsback and Robert Lacault project, "How to Build a Radiotrola"[15]. Gernsback first wrote about the Radiotrola concept in an editorial, and explained the need of making radios easier to operate, with a minimum of controls before they would get wide spread public acceptance (Figure 2) [16]. The Radiotrola was constructed by Lacault and Gernsback, to be used by Gernsback, and had battery storage, receiver, horn speaker, and loop antenna integrated into a single cabinet. By building the Radiotrola the authors demonstrated that a radio could be made that was simple to operate, and could be a viable alternative to the phonograph as entertainment for the home. Gernsback would later be credited as the first to have designed

a radio containing these features in a single housing.

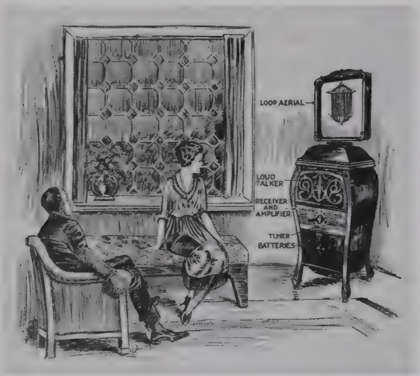


Figure 2. A conceptual drawing of the Radiotrola from the December 1921 issue of *Radio News*. p. 494.

Most of Lacault's work appeared in *Radio News*, with over 15 articles published. Some of these articles would also be seen reprinted in newspaper radio columns [17]. Hugo Gernsback's publishing empire published many different magazines and it is likely that Lacault had some articles in other publications besides *Radio News* and *Science and Invention*. Besides magazine articles, Lacault authored at least one booklet on radio construction while working for Hugo Gernsback [18].

Outside his work at *Radio News*, Lacault must have been an engineering consultant; one example of a product he designed was the RASCO RF Transformer (Figure 3). In an early 1924 RASCO catalog the following was included in the description of the RASCO RF Transformer, "Our Radio Frequency Amplifying Transformer, which has been developed and designed for us by Mr. Robert E. Lacault, Associate Editor of *Radio News*, is the latest word in this style of transformer"[19]. Lacault must have enjoyed designing RF transformers because he would design and sell RF transformers for almost every radio kit he developed.

Phenix Radio Corporation

Phenix Radio appears to have come on the radio scene shortly after Lacault introduced his Ultradyne circuit. The first Phenix Radio Corporation ad that I have found was run in the March, 1924 *Radio News* (Figure 4). This was a month after Lacault published his first Ultradyne article in *Radio News*, "The Ultradyne Receiver" [20]. Phenix Radio at this time was located at 3-7 Beekman Street, New York City. They would have two other addresses in New York, at 114-B East 25 Street, and 164-B East 25 Street before going out of business in 1926. Phenix Radio Corporation

Figure 3. Ad for the Lacault designed RASCO RF Transformer. (*RASCO Catalog*, Radio Service Company, 1924) From the library of Richard Ammon.

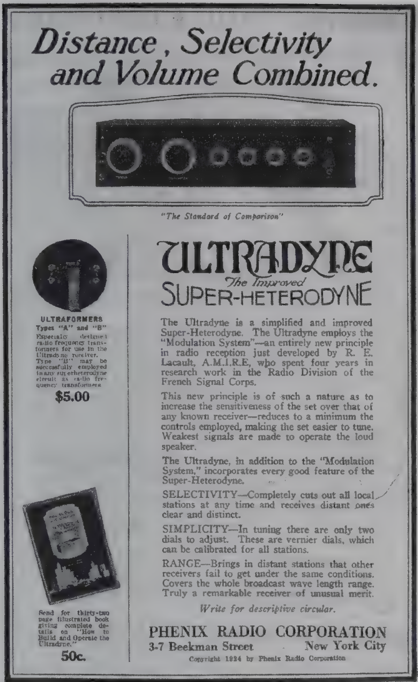


Figure 4. The first Phenix Radio advertisement to appear in *Radio News*. (*Radio News*, March 1924, p. 1367)

was incorporated on June 23rd, 1925 by owners W. A. Eisenhauer, A. Stevens, and S. Franklin. Capitol on hand at incorporation was $215,000 [21].

Phenix Radio called themselves "Designers and distributors of high grade radio apparatus". They sold not only Lacault designed kit radios, but also radio accessories and parts. They could provide you with Eveready storage batteries, Bristol horn speakers, Pacent head phones, and loop antennas from Mathieson. Phenix used Teleradio Engineering Corporation to make the various coils for the Ultradyne L-2. The Lacault designed Ultra-Vernier dial was sourced from Hammarlund Manufacturing Company [22]. There is no manufacture information on the Lacault Ultraformers, but I expect they were not made by Phenix Radio. I have not been able to determine if Phenix Radio had any manufacturing capability. Robert Lacault would leave *Radio News* as the Associate Editor and become the Chief Engineer of Phenix Radio Corporation around the same period as Phenix Radio would incorporate. The April 1925 issue of *Radio News* is the last edition that lists Lacault as the Associate Editor [23]. Phenix must have thought that Lacault's name was a powerful marketing tool because they used his name on all of their ads. Phenix also would use a Lacault monogrammed seal on their product line as a guarantee of Lacault design. While at Phenix Radio, Lacault would be credited for designing the Ultra-Vernier Tuning Control, an Ultra-Lowloss Condenser, and the Ultradyne L-3 Receiver.

With the Ultradyne L-3 Receiver Phenix would attempt to transition from radio kit supplier to designing, and selling a manufactured radio. The L-3 was a departure from previous Lacault designs in that it was not a superheterodyne, and therefore did not use the modulator circuit which Lacault had built his fame upon. The Ultradyne L-3 would be the last radio model to be marketed by Phenix. By June 1926, Phenix Radio advertisements are no longer run in *Radio News*, and on July 26th, 1926, a bankruptcy auction was held to sell the remaining assets [24]. Their Chief Engineer, Robert Lacault had already found other employment

opportunities before the collapse of Phenix Radio, and would continue to sell radio products and to design new radio circuits.

Keystone Radio Service

An article appeared in the *New York Sun* titled, "Lacault Forms New Service Organization," which leaves the impression that Lacault had started his own business, or accepted a job in direct competition with Phenix Radio [25]. The Keystone Radio Service sold complete radios, kit radios, radio parts and accessories (Figure 5). Keystone ad graphics often used the same art that Phenix Radio used for their Ultradyne ads, and it is likely that the Ultradyne kits were supplied by Phenix, and not assembled by Keystone. Many of the parts sold by Keystone were also specified for constructing the Ultradyne L-2, like Hammarlund condensers, and NA-ALD tube sockets. Keystone Radio Service ads claimed that all of the products that they sold had been tested and approved by Lacault. Keystone also scheduled customer's private appointments with Robert Lacault so they could tap "his vast scientific experience" [26]. A company by the same name existed in New York as late as 1946 but there is no evidence that they are one and the same.

Figure 5. Keystone Radio ad for the Ultradyne L-2 kit. (*Radio News*, January 1925, p. 1286)

The Ultradynes

The Ultradyne name was used for a group of radios designed by Robert Lacault during the years 1924 and 1925. All were superheterodynes and available as kits, with the exception of the model L-3. This was a tuned radio frequency or TRF type of receiver and was only available as a complete, factory built radio. There were a number of radio distributors besides Phenix Radio that marketed Ultradyne kits, and sold separate parts to construct the Ultradyne circuit. Three that quickly come to mind are the Madison Radio Corporation, The Broadcast Service Company, and the before mentioned Keystone Radio Service. All of the Ultradyne superheterodyne models used Lacault's modulation system. Ed Lyon explained the Lacault modulator circuit: "Lacault simply replaced the Armstrong heterodyne detector, or rectifier, with a multiplying circuit. Such circuits were not new to radio; they were called modulators, and were used in all broadcast transmitters to place the program signal on the radio-frequency carrier" [27]. Lacault applied for U.S and Canadian patents for his circuit in 1924. The Canadian patent 258413 was approved on February 23, 1926, with ownership assigned to Phenix Radio Corporation, but the U.S. Patent Office

did not complete the approval process until many years later.

There are a few different versions of the Ultradyne sold by companies not associated with Phenix Radio, or Robert Lacault. After Phenix Radio closed its doors, the Ultradyne name continued to be used as a radio brand. The Brooklyn-based company, Traul, sold kit radios using the Ultradyne name during the early 30's, and later Regal would also use the name [28]. My focus here is to review the radio models that were actually designed by Lacault and sold through Phenix Radio.

Ultradyne – Original Circuit

Radio News published Lacault's first Ultradyne article titled "The Ultradyne Receiver" in the February 1924 issue [29]. It details the theory of operation and construction of a six tube superheterodyne receiver, including instructions for making the oscillator coil, tuning coil, and the IF transformers. A follow up article in the March *Radio News* would continue the project with the construction of a separate two stage audio amp [30]. Lacault wrote a third article which included information on winding coils so that the Ultradyne could be used to receive short waves [31]. Construction plans were also published later in the *Radio News Superheterodyne Book*. Shortly after the publication of the February article, Phenix Radio Corporation appears with ads in *Radio News* offering a kit for the six tube Ultradyne. The illustration of the Ultradyne in the February *Radio News* article clearly shows the Ultradyne using the tuna can shaped Ultraformer RF transformers that were sold by Phenix Radio. Lacault tells the readers only, "The radio frequency transformers may be of any suitable type designed for long wave reception." Lacault continues to explain that the builder can construct the ones pictured which are of a special design, except the drawings provided to make these RF transformers look nothing like the ones in the illustration. Apparently they must not have been available in sufficient quantities otherwise Lacault would have recommended to use the Ultraformers. For tubes, Lacault recommended that the builder use type 201-A tubes, and that the oscillator should use a 216-A, or a VT-2 tube. This first version of the Ultradyne is rare compared to the later models.

Ultradyne L-1

Before the March 1924 issue of *Radio News* was on the newsstands, the original Ultradyne was obsolete. The March *Radio News* ran the second part of the original Ultradyne project. Also appearing was Phenix Radio's first ad for a new 8 tube Ultradyne [32]. The Phenix Radio advertisement offered a 32 page illustrated book, and IF transformers called "Ultraformers" for the newly designed radio. This radio was basically the original Ultradyne but incorporated the separate two stage audio amp into a single cabinet. Phenix Radio sold kits, and separate parts, including an engraved front panel, and IF transformers. You can identify the model L-1 from other Ultradyne models

by the 4 filament controls which are to the right of the tuning knob, and by the black Bakelite, tuna fish can shaped IF transformers.

Ultradyne L-2

Lacault followed up Ultradyne L-1 with the Ultradyne L-2, a kit radio which came out in late 1924. The L-2 was an eight tube superheterodyne which was advertised as utilizing both modulation and regeneration. Phenix Radio sold the basic Ultradyne kit for $30.00, which included the tuning coil, oscillator coil, Ultraformer IF's, and four fixed condensers. You could also buy the Ultradyne L-2 as a complete kit, excluding tubes for $97.00. Phenix Radio also offered a 32 page illustrated book, *How to Build and Operate the Ultradyne*, written by Lacault (Figure 6) [33]. You can identify the L-2 by its brown tuna can Ultraformer IF's, and the use of Amperite self adjusting rheostats which eliminated the need for multiple filament controls on the front panel. A properly equipped L-2 will use Hammarlund tuning condensers with Accuratune or Ultra-Vernier tuning knobs (Figure 7). The L-2 must have been very popular since it is one of the most commonly seen superheterodynes from the 1920's.

Not all reviews for the Ultradyne were positive. The amateur radio publication *QST* challenged Lacault by arguing that the Ultradyne functioned in

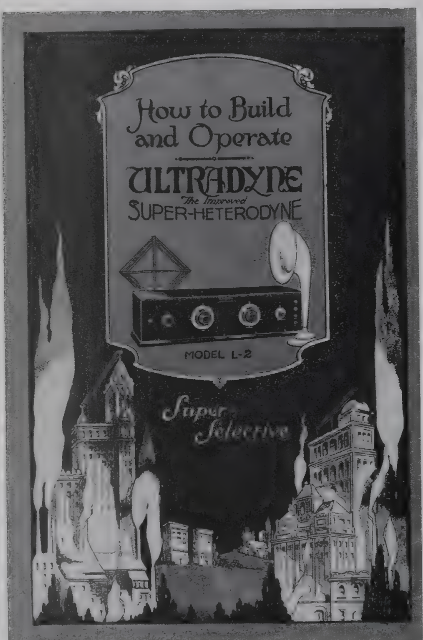


Figure 6. Cover art of the Ultradyne L-2 booklet.

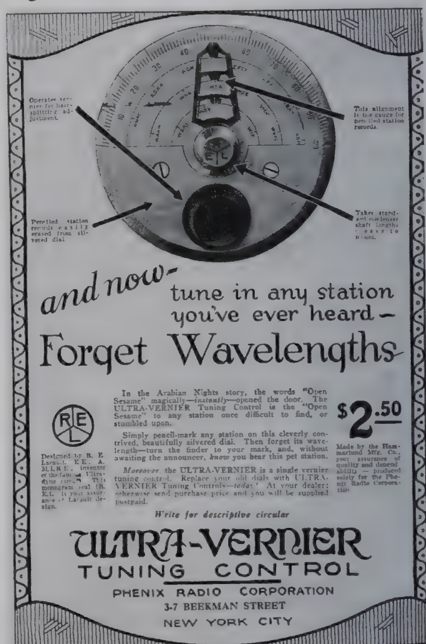


Figure 7. Ad for the Lacault designed Ultra-Vernier dial sold by Phenix Radio. (*Radio News*, January 1925, p. 1303)

the same manner as other superheterodynes, "It should be pointed out here that the performance which takes place is not what one would ordinarily describe as modulation. The incoming frequency and the oscillator frequency are mixed in the plate circuit of the first tube in quite the usual fashion and the resulting intermediate frequency is produced by rectification in quite the usual fashion also". The writer was also somewhat critical of the Ultradyne's performance and offered changes to Lacault's circuit [34]. Lacault responded, giving us a chance to see his personality. Jumping on *QST* for misspelling his name, Lacault wrote, "However, I wish to point out that my name is not LeCault, but LACAULT" and he signed his letter, "I remain, R.E. Lacault" [35]. This exchange is the only case that I have ever detected emotion in Lacault's writing, and apparently he did not like his name to be misprinted.

Ultradyne L-3

The Ultradyne L-3 hit the market during the fall of 1925, and was the only Lacault designed radio that was not a homebrew, or kit. Radio News described Lacault's new radio in the article "New Ideas In Receivers", and Phenix Radio ran a huge two page ad for the L-3 with a banner which read, "R.E. Lacault Leads Again!" [36] [37]. With the L-3 Lacault strived to design a radio that was user friendly, not unlike the Radiotrola, which lacked the numerous controls that made radios of the period look like laboratory equipment. At a glance the L-3 looks more like a speaker cabinet than a radio (Figure 8). It was a Tuned Radio Frequency type of receiver which had no front panel, no tuning knobs, and a horn integrated into the cabinet. The L-3 tuning condensers were operated by levers, and the dial scale was molded into the outer edge of the speaker grill. The tuning levers operated a pair of Lacault designed, Ultra-Lowloss Condensers which were mounted on the backside of the chassis, and connected to the levers via control shafts which passed through the horn body (figure 9A and 9B). The six tube Ultradyne L-3 was available as a table radio for \$135.00 or as a console for \$175.00. The L-3 was the last receiver marketed by Phenix Radio and could have been the cause of their demise. By June of 1926, the remaining stock of Ultradyne L-3's was heavily discounted for as little as \$33.00 [38]. Today the L-3 is considered rare, and only a few examples are known to exist. The most likely reason that there are so

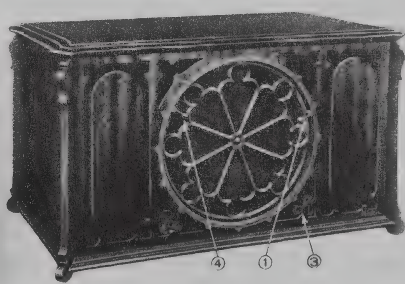


Figure 8. The Ultradyne L-3 has two tuning control levers which are indicated at positions 1 and 4. The number 3 position is the location of the volume control. (*Radio News*, October 1925, p. 431)

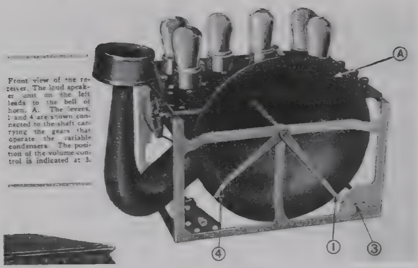


Figure 9A. A forward view of the ultradyne L-3 chassis showing how the tuning control levers are arranged. (*Radio News*, October 1925, p.431)

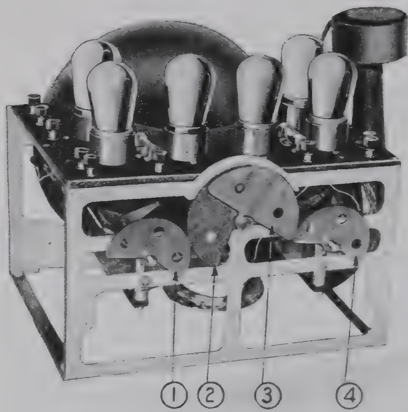


Figure 9B. Rear view of the Ultradyne L-3 chassis. Gears 2 and 3 are attached to the tuning control levers while gears 1 and 4 drive the tuning condensers. (*Radio News*, October 1925, p. 431)

few surviving Ultradyne L-3's is that the Lacault Lowloss Condenser frame was a light weight design, made of pot metal and prone to break (Figure 10) [39]. The same can be said for the L-3's ornate and delicate pot metal speaker grill. The failure of these fragile parts most likely sent almost all of the L-3's to the dump. The L-3 in my collection, serial number 07163, has both a broken grill and damaged condensers, rendering it unusable.

Radio Electric Laboratories

As the Phenix Radio Company was filing for bankruptcy Robert Lacault was starting a new radio sales business, the Radio Electric Laboratories, or REL with an address of 1581 Macombs Road, New York. Radio Electric Laboratories would have several business addresses between June 1926 and its demise, the last being 1931 Broadway, New York. Radio Electric Laboratories sold radio kits, battery eliminator kits, parts, and photographic equipment. Lacault also re-wired customers radios for power tubes, installed shielding, and did complete re-builds of receivers [40]. Robert continued his association with *Radio News*, regularly running Radio Electric

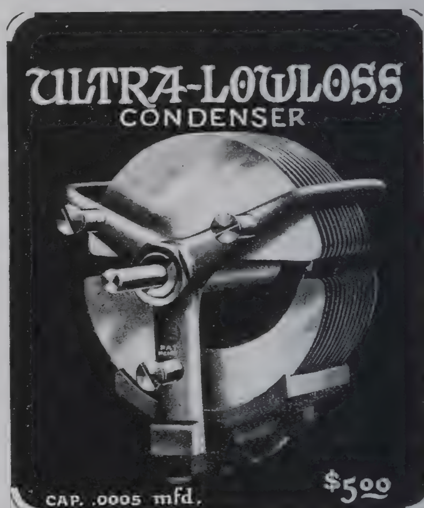


Figure 10. This illustration from a Phenix Radio ad shows the delicate pot metal frame of the tuning condenser used in the Ultradyne L-3 radio. (*Radio News*, December 1925, p. 849)

Laboratories radio ads and submitting radio construction articles. The radios that he designed during this period were all superheterodynes with one exception, a small three tube receiver.

LR4

The first Lacault radio design offered by REL was the model LR4 receiver with its construction detailed in a book

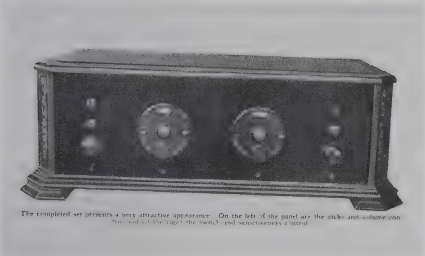


Figure 11A. This illustration is from Lacault's book that details the construction of the LR-4. The crooked image is an error original to the book. (*Super Heterodyne Construction and Operation*, 1926, p. oop. P.74)

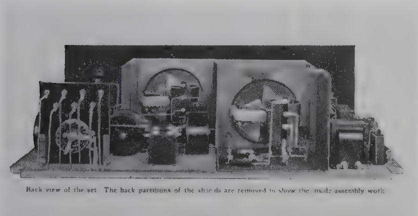
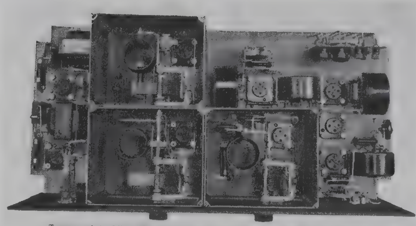


Figure 11B. The rear view of the LR-4 receiver chassis. (*Super Heterodyne Construction and Operation*, 1926, p. oop. P.80)

authored by Lacault, *Super Heterodyne Construction and Operation* (Figures 11A-C). This book provided readers with some basic electronics theory, principles of superheterodyne operation, troubleshooting radio circuits, and assembly instructions for building



Top view of the LR4 receiver showing the arrangement of the parts on the baseboard

Figure 11C. The downward view of the LR4 receiver chassis. (*Super Heterodyne Construction and Operation*, 1926, p. oop. P.88)

the LR4 receiver [41]. We see the first ads for *Super Heterodyne Construction and Operation*, and the LR4 in late 1926, and *Radio News* publishing Lacault's LR4 construction article in their January 1927 issue [42]. A follow-up article appeared in the April issue of *Radio News* which covered the construction of a battery eliminator for the LR4 [43]. The nine tube LR4 was like other Lacault designs and was constructed on a baseboard of wood with the components attached with wood screws. What was different from the earlier Ultradyne sets was that the LR4 employed shielding. The recommended tubes for the LR4 were UX201A with a UX112 in the last stage of the audio amplifier. If the constructor wished, they could also build the combined power amplifier and B battery eliminator. Today the LR4 is an uncommon set. I know of only one example in a collection but there are likely others that have not been identified because they are kits, and may not have engraved front panels.

Strobodyne

Though not a radio designed by Lacault, the Strobodyne is very much associated with him. *Radio News* published the first Strobodyne article in their July 1927 issue (Figure 12) [44]. The following month there were an additional three pieces written regarding the Strobodyne. One was written by Lacault, "The Stroboscope and its Operation" and another, "Design of a Simple Stroboscope" was authored by Hugo Gernsback. Both of these were articles explaining stroboscopic action and how it related to the operation of the Strobodyne receiver. The third article, "Construction of the 8-Tube Strobodyne Receiver," was the main article providing the instructions and diagrams for building the Strobodyne, which *Radio News* proclaimed as "The Years Greatest Circuit"[45][46][47]. The Strobodyne receiver was conceived by Professor Lucien Chretien, who had written articles for the French radio magazine *TSF Moderne*. After much searching, it could not be determined if Chretien had served in the French Signal Corps as had Lacault. Though there is no evidence to indicate that Lacault and Chretien knew each other, it is very likely they did, and this may have been one reason that Lacault translated Chretien's article, and adapted the construction plans for use in America. Radio Electric Laboratories would market the Strobodyne, and would sell the Lacault designed plug-in RF coils, plans, and other specified parts to construct the Strobodyne.

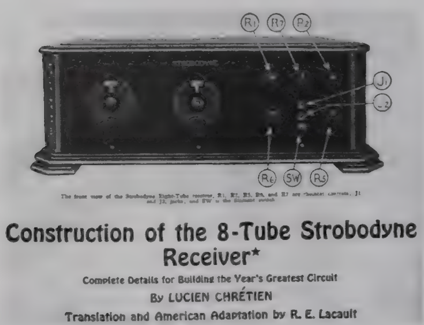


Figure 12. This drawing shows the front panel layout of the eight tube Strobodyne receiver. The Strobodyne construction plans were modified by Lacault for the North American market. (*Radio News*, August 1927, p. 132)

The Strobodyne is an eight tube superheterodyne receiver which used UX201A tubes and an UX112 for the final audio amplifier. *Radio News* described its operation as follows, "The Strobodyne operates not by causing two frequencies to beat; but by providing a conductive path for the signal only during the phases of suitable polarity in the oscillating circuit which operates in the frequency changer" [48]. Like Lacault, Lucien Chretien had developed another solution to frequency conversion for a superheterodyne, but he would not continue to use his circuit in additional models for the American market.

With the Strobodyne, Lacault departs from past radio construction projects in that the Strobodyne does not utilize the normal wood baseboard construction as was used with the Ultradyne kits. Instead, it uses a Bakelite sub panel for component mounting. This allowed for some components to be mounted to the underside, and for component wiring to be run from below. The Strobodyne sub panel is

drilled and wire connections with components on the topside of the sub panel are made through wire hoops that are stuck through these holes. This type of wiring is referred to in *Radio News* as the "golf system of wiring". All of the wiring on the underside of the sub panel is directly wired, point to point, and the only place you will find the old style bus bar connections are on the topside of the sub panel. Like the LR4, the Strobodyne employs shielding of the RF and oscillator stages.

Radio News would publish another article in September 1927 which would describe how to adapt the Strobodyne for operation with a loop antenna, and the use of an A.C. power unit [49]. Strobodyne construction articles also appeared in other radio publications. One would think that examples would be available today, but that is not the case. As with all of the Lacault radios offered after the Ultradyne L-2, there are few survivors today.

All-Wave Electric 9

Radio Electric Laboratories started selling their first fully AC powered superheterodyne radio kit in early 1928 (Figure 13). Introduced by *Radio News* in February 1928, the All-Wave Electric 9, or R.E.L. 9, was radically different from previous REL offerings [50]. The R.E.L. 9 was a twelve tube, shielded receiver, and had a separate amplifier-power unit utilizing a push-pull pair of UX210 tubes to supply the audio. Again, Lacault used his modulation system made famous by his original Ultradyne receiver. A new feature for a Lacault radio was the use of plug-in RF coils which could be swapped out to change bands. These plug-in coils extended the coverage of the R.E.L. 9 beyond the broadcast band so that listeners were able to tune the short-wave and amateur frequencies as well. What makes the R.E.L 9 so different from other radios of its time was the type of tubes it used. Lacault picked Sovereign AC tubes, which have filament power applied to the top of the tube in the same manner as a Kellogg tube. Few radios used Sovereign tubes and it makes one wonder if Lacault picked these tubes to avoid using RCA types. Even the outboard audio amplifier/power supply used non RCA tubes, having specified the use of CeCo brand tubes. Considering how often RCA sued many small companies over patent infringements, he may have decided to give his business to RCA competitors. There could also have been bad blood between RCA and Lacault if RCA had challenged his patent application for his Modulator Circuit. The why behind the reason Lacault decided not to use RCA

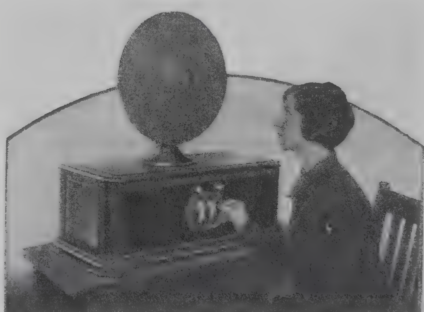


Figure 13. A photo of Lacault's All Wave Electric 9. (*Radio News*, February 1928, p. 908)

tubes will likely never be known, but the results, the combination of a superheterodyne receiver with plug-in coils, and utilizing Sovereign vacuum tubes makes the R.E.L. 9 a very unique radio. Another radio that would appear to be identical to the R.E.L. 9 is the Ultradyne A.C. Commander. The A.C. Commander was introduced in the March 1928 issue of the *Citizen Radio Call Book* [51]. Externally they look alike, using the same style of cabinet, and Tyrman Electric Company sourced dual drum dial. While both the R.E.L. 9 and the A.C. Commander used Sovereign tubes, internally there are differences in the types, and layout of components. Where the R.E.L. 9 uses REL supplied RF coils the A.C. Commander uses the older style RF coils that had been sold by Phenix Radio. Considering that the A.C. Commander was never advertised in *Radio News* by Lacault, and did not use his REL plug-in coils, it is likely that the A.C. Commander was not a Radio Electric Laboratory design.

Calibrated Short Wave Set

Around June of 1928 Lacault would offer a short wave receiver called the "Calibrated Short Wave Set" (Figure 14) [52]. The only information beyond magazine ads can be found in D.H. Moore's monograph, *The Ultradynes*. Here you will find schematics for several three tube Short wave receivers which he cites CB-III-2 as his only reference. I have never found any material that supports Mr. Moore's data on any of the Lacault short wave sets.

Screen-Grid Strobodyne

In the fall of 1928 Lacault would re-visit the Strobodyne design, and modify it for use with the newly released screen grid type 22 tube. Lacault authored his typical article detailing the construction of the new Screen Grid Strobodyne but warned the readers, "The Screen-Grid Strobodyne is not a kit receiver, and its construction cannot be described in that manner". This is because there were no suppliers selling pre-drilled panels or any other fabricated pieces. Lacault also did not supply the various RF coils through Radio Electric Laboratories as he had in the past, and left it to the builder to make their own. In an effort to make sure that would be builders fully understood the challenges they faced with winding their own coils, Lacault wrote "The experimenter who does not possess the facilities of matching these coils is

Figure 14. The Calibrated Short Wave Set was available from Radio Electric Laboratories in 1928, but no period documentation has been found by the author. (*Radio News*, July 1928, p. 69)

advised not to attempt their construction." The Screen-Grid Strobodyne was an eight tube receiver using three type 22 tubes, two type 201A tubes, one type 112A, and a pair of 171A's for the audio amplifier. Components of the Screen-Grid Strobodyne were laid out on a baseboard with much of its wiring located on its underside [53]. It is unlikely that many Screen-Grid Strobodynes were built considering the skills that were required to construct one.

RE 29

Radio News published Lacault's last article, RE 29 in their June, and July 1929 issues [54] [55]. The article explained the construction of the RE 29 in great detail, and listed all the suggested parts, and provided schematics, chassis layout diagrams, and photographs of the receiver (Figure 15). In the article, *Radio News* states, "Mr. Lacault died just after completing the article. He left a sketch and some information on constants for an external automatic volume control to be used with the installation." The combined schematic for the amplifier, power supply, and AVC is illustrated in (Figure 16A). *Radio News* included an addendum to Lacault's article for the automatic volume control. Also the article mentions that the RE 29 was available in kit form, and Alice Lacault ran an ad in *Radio News* selling plans and parts for the RE 29 [56].

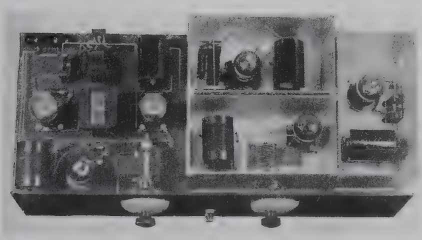


Figure 15. A downward view of the RE 29 chassis. The power supply, audio amplifier, and AVC circuitry are located on a separate chassis. (Radio News, June 1929, p. 1090)

The RE 29 consisted of a receiver, and an external amplifier/Power supply. The receiver cabinet had six tubes, three of which were type 22 screen-grid tubes, making the RE 29 the only Lacault radio to incorporate the modulator detection system with screen-grid tubes. In fact the actual modulation tube was a type 22 but used as a triode by joining together the tubes plate and screen-grid (Figure 16B). The audio amplifier used a pair of type 210 tubes, and the power supply used a pair of type 281 tubes for rectifiers. The construction was similar to previous Lacault radios in that the components were mounted on a baseboard and that shielding provided isolation to the different stages were needed. The RE 29 was the last of a line of Lacault designed superheterodyne receivers which began with the *Radio News* article, "Construction of Super-Heterodyne Receivers" in 1923 [57].

Final Days

Robert would live in Bronxville, New York for his last year, and die from an undisclosed illness which he suffered with for about two months. He would die on March 12, 1929 at the age of 31 [58]. His obituary said he was survived

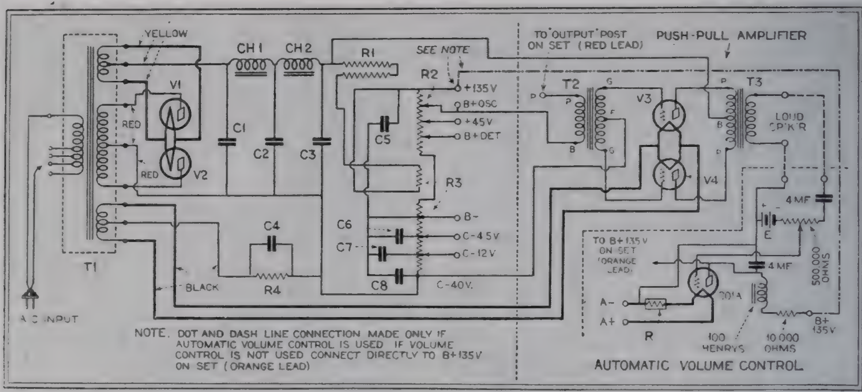


Figure 16A. The Schematic of the RE29 power supply, audio amplifier, and automatic volume control circuit. (Radio News, July 1929, p. 55)

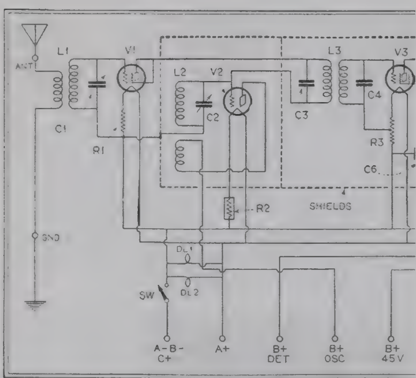


Figure 16B. This schematic of the RE-29 shows how the modulation tube V1 is being used as a triode, with the plate and screen-grid tied together. (Radio News, June 1929, p. 1092)

by his wife Alice, and there is no mention of any others. The 1930 censes also shows Alice as the sole resident, and so it appears that they never had children. A Christian Science service was held on March 14th, at the McGrath Funeral Home in Bronxville, NY [59]. Today Robert Lacault's cremated remains repose in niche 2821 in the Marble Columbarium, at the Fresh Pond Crematory, Middle Village, NY [60].

I found it surprising that Lacault, who was listed in Ellis Island records as being Hebrew, would have become a Christian Scientist. A Christian Scientist receives healing through prayer, and opposes science, an interesting stand for someone who was an inventor and engineer. The final cause of death may forever remain a mystery because of Lacault's religious practices, and he likely never received treatment, or medical diagnosis.

Robert Lacault never did live to see his "Radio Receiving System" patent, 1,740,946 awarded. Alice Lacault sold Robert's modulator patent to RCA the day it was patented, December 24th, 1929. She would continue to live in the New York area, finding a job with the Great Atlantic Tea Company. Alice never remarried, and passed away in March 1971 at the age of 77. Social Security records show her last residence to have a 10017 zip code, Manhattan, New

York. With the passing of Alice, so did the memory of Robert Lacault, and an unwritten chapter in the history of radio.

Conclusions

It is undisputable that Robert Lacault served in the French Signal Corps during World War One. What he did during his service is less clear because his tasking is not defined in his military records. The work environment at the Eiffel Tower facility may have been hostile to people who worked on the superheterodyne project when it came to getting recognition for their work. An example of office politics would be Paul Laut who had accused Lt. Levy of taking credit for his work, and applying for a patent that he, Paul Laut had described in his notes. Paul Laut states he approached then Colonel Ferrie and, "He reminded me that we were at war and that any disagreements between French scholars and engineers would be out of place" [61]. What we have pieced together from ads and from Lacault's own words would indicate that he worked directly under General Ferrie, who was the overall supervisor of the French superheterodyne development team. Lacault also told readers that he had worked on reflex amplifiers during the war, which were designed by Marius Latour, a principle member of the superheterodyne team. Another clue to Lacault's wartime work can be found in the booklet *How to Build and Operate the Ultradyne* which, in its introduction states that Lacault was in fact doing research work, "Among others of the group doing research work was Robert E. Lacault, who served four years in the French Signal Corps." There is also reference to Lacault doing research work, "on the first reflex amplifiers and conducted extensive experiments with short wave wired radio and radio compass equipment" [62]. The last claim is the most telling as it states, "Since the war Mr. Lacault has devoted his efforts to further develop his former research work on superheterodyne receivers". My conclusion is that Lacault was not a key member of the superheterodyne development team but he may have made contributions to the effort. If he did make a contribution it most likely came from his work with reflex amplifiers, which not only serve a role in radio, but also in ground telegraphy [63]. Regardless of Lacault's wartime role, his experience working with the signal corps gave birth to his modulator circuit, and ultimately the award of Canadian and U.S. patents. Webster's Dictionary defines a pioneer as, "a person who experiments and originates, or plays a leading part in the early development of something. Though Lacault does not qualify as playing a leading role in radio, I hope you agree with me that he was one who originates, and experimented during the early days of radio development, and is one of radio's early pioneers.

References

1. "Record of Birth – Robert Emile Lacault," Genealogy research package from Robert Van-Ghele, received Sep. 2006.
2. Ross Radnor, "Those Were Thrilling

Days in Radio When R.E. Lacault Was an Amateur," *The Davenport Democrat and Leader*, Davenport, IA., 10 May, 1925, p. 25.

3. Alphabetical repertory of the mobilization of the men living in the 2nd District of Paris, Genealogy research package from Robert Van-Ghele, received Sept. 2006.
4. "Military service record – Robert Emile Lacault," Genealogy research package from Robert Van-Ghele, received Sept. 2006.
5. Phenix Radio Corporation pamphlet, Ultradyne Model L-2
6. *Radio News*, Vol. 10, No. 12, June 1929, p. 1130. (Alice Lacault R.E. 29 advertisement.)
7. Robert E. Lacault, "Practical Notes On Reflex Amplifier Construction," *Science and Invention*, Vol. 11, No. 4, Aug. 1923, p. 368.
8. Ross Radnor, "Those Were Thrilling Days in Radio When R.E. Lacault Was an Amateur," *The Davenport Democrat and Leader*, Davenport, IA., 10 May, 1925, p. 25.
9. "Ellis Island Passenger Record – Robert Lacault," Online search engine result, 11 Oct. 1920.
10. D.H. Moore, *Vintage Radio Identification Sketch-Books of D.H. Moore , Ultradyne Monograph* (The Editorial Group, Ltd., 1987) p. 1.
11. Robert E. Lacault, "Radio Constructor: A Three Tube Combination Radiophone Transmitter and Receiver," *Radio News*, Vol. 2, No. 6, Dec. 1920, p. 368.
12. Robert E. Lacault, "Jazz from the Air," *Science and Invention*, Vol. , No. , Jan. 1922, p. 842.
13. Robert E. Lacault, "The Belin Radio-Television Scheme," *Science and Invention*, Vol. 10, No. 12, Apr. 1923, p. 1166.
14. Albert Abramson, *Zworykin, Pioneer of Television* (Board of Trustees of the University of Illinois, 1995) p. 219
15. Robert E. Lacault, "How to Build a Radiotrola," *Science and Invention*, Vol. , No. , Mar. 1922, p. 1041.
16. Hugo Gernsback, "The Radiotrola," *Radio News*, Vol. 3, No. 6, Dec. 1921, p. 479.
17. Robert E. Lacault, "Best Methods of Radio Amplification," *The Morning Herald*, Gloversville, NY., 23 Aug. 1922, p. 6.
18. Robert E. Lacault, *How to Make Radio-Phone Receiving Sets* (The E. I. Company, 1923)
19. *RASCO Catalog*, (Radio Service Company, 1924)
20. Robert E. Lacault, "The Ultradyne Receiver," *Radio News*, Vol. 5, No. 8, Feb. 1924, p. 1058.
21. "New Incorporations," *New York Times*, 23 Jun. 1925, p. 36.
22. *Popular Radio*, Vol. 7, No. 1, Jan. 1925, p. 110. (Phenix Radio Corporation advertisement.)
23. Hugo Gernsback, "Editorial," *Radio News*, Vol. 6, No. 10, Apr. 1925, p. 1845.
24. *New York Times*, 26 Jul. 1926, p. 31.
25. "Lacault Forms Service Organization," *The New York Sun*, 7 Feb. 1925, p. 30.
26. *New York Sun*, 7 Feb. 1925, p. 11. (Keystone Radio Service advertisement.)
27. Ed Lyon, "Probably a Whole Lot More Than You Ever Wanted to Know About the Superheterodyne Receiver – Part III," *Mid-Atlantic Antique Radio Club Newsletter*, Mar. 1987, p. 5.
28. *Radio Craft*, Vol. 2, No. 12, Jun. 1931, p. 753. (Traul Radio Company advertisement.)

29. Robert E. Lacault, "The Ultradyne Receiver," *Radio News*, Vol. 5, No. 8, Feb. 1924, p. 1058.
30. Robert E. Lacault, "The Ultradyne Receiver-Part 2," *Radio News*, Vol. 5, No. 9, Mar. 1924, p. 1234.
31. Robert E. Lacault, "Notes on the Ultradyne Receiver," *Radio News*, Vol. 5, No. 10, Apr. 1924, p. 1419.
32. *Radio News*, Vol. 5, No. 9, Mar. 1924, p. 1367. (Phenix Radio Corporation advertisement.)
33. Robert E. Lacault, *How to Build and Operate the Ultradyne Model L-2* (The Phenix Radio Corporation, 1924)
34. S. Kruse, "Building Superheterodynes That Work-Part III," *QST*, Vol. 8, No. 1, Aug. 1924, p. 18.
35. Robert E. Lacault, "Letter to Editor," *QST*, Vol. 8, No. 4, Nov. 1924, p. 70.
36. G. C. B. Rowe, "New Ideas In Receivers," *Radio News*, Vol. 7, No. 4, Oct. 1925, p. 430.
37. *Radio News*, Vol. 7, No. 4, Oct. 1925, p. 402-403. (Phenix Radio Corporation advertisement.)
38. *New York Times*, 20 Jun. 1926, p. XX19. (Edzin advertisement.)
39. *Radio News*, Vol. 7, No. 6, Dec. 1925, p. 849. (Phenix Radio advertisement.)
40. *New York Sun*, 11 Sept. 1926, p. 47. (Radio Electric Laboratories advertisement.)
41. Robert E. Lacault, *Super Heterodyne Construction and Operation* (Radio Electric Laboratories, 1926)
42. Robert E. Lacault, "The New Shielded Ultradyne," *Radio News*, Vol. 8, No. 7, Jan. 1927, p. 812.
43. Robert E. Lacault, "A Complete A and B Socket Power Unit," *Radio News*, Vol. 8, No. 10, Apr. 1927, p. 1226.
44. Lucien Chretien, "The Strobodyne Circuit," *Radio News*, Vol. 9, No. 1, Jul. 1927, p. 28.
45. Robert E. Lacault, "The Strobodyne and its Operation," *Radio News*, Vol. 9, No. 2, Aug. 1927, p. 130.
46. Hugo Gernsback, "Design of a Simple Strobodyne," *Radio News*, Vol. 9, No. 2, Aug. 1927, p. 131.
47. Robert E. Lacault, "Construction of the 8-Tube Strobodyne Receiver," *Radio News*, Vol. 9, No. 2, Aug. 1927, p. 132.
48. Lucien Chretien, "The Strobodyne Circuit," *Radio News*, Vol. 9, No. 1, Jul. 1927, p. 28.
49. Lucien Chretien, "Loop Operation of the Strobodyne Receiver," *Radio News*, Vol. 9, No. 3, Sept. 1927, p. 228.
50. Robert E. Lacault, "The All-Wave Electric 9," *Radio News*, Vol. 9, No. 8, Feb. 1928, p. 908.
51. "The A.C. Commander and Power Amplifier," *Citizen Radio Call Book*, Vol. 9, No. 2, Mar. 1928, p. 105.
52. *Radio News*, Vol. 10, No. 1, Jul. 1928, p. 69. (Radio Electric Laboratories advertisement.)
53. Robert E. Lacault, "The Screen-Grid Strobodyne Receiver," *Radio News*, Vol. 10, No. 3, Sept. 1928, p. 235.
54. Robert E. Lacault, "The RE 29 Receiver," *Radio News*, Vol. 10, No. 12, Jun. 1929, p. 1090.
55. Robert E. Lacault, "The RE 29-Part Two," *Radio News*, Vol. 11, No. 1, Jul. 1929, p. 53
56. *Radio News*, Jun. 1929, p. 1130. (Alice Lacault advertisement.)
57. F. de Willy and Robert E. Lacault, "Construction of Super-Heterodyne Receivers," *Radio News*, Vol. 5, No. 6, Dec. 1923, p. 690.

58. "Deaths," *The Yonkers Statesman*, 15 Mar. 1929, p. 6.
59. "Resident Dies at Home Here," *The Daily Argus*, Mount Vernon, NY., 14 Mar. 1929, p. 14.
60. Fresh Pond Crematory, letter to author, 24 Nov. 2012
61. Robert Champeix, trans. Richard Foster, "Who Invented the Superheterodyne?," *The AWA Review*, 1991, vol. 6, p.98.
62. Robert E. Lacault, *How to Build and Operate the Ultradyne Model L-2* (Phenix Radio Corporation., 1924) p. 3.
63. Ernest H. Hinrichs, *Listening In* (White Mane Publishing Company, Inc., 1996) p. 118.

Acknowledgements

I am very grateful to my family for their help and support while I worked on this article, and especially to Lisa Flower who did the editing. Many subject matter experts within the antique radio community contributed their time and knowledge to this effort. My friend and expert on the subject of early superheterodynes, Richard Ammon, shared with me his knowledge of the Phenix Radio Company and their different Ultradyne models, and provided some of the illustrations. Thanks to Alan Douglas who provided the patent information, the Ultradyne monograph, and, other assistance. Dale Davenport gave a lot of his time digging up information. Dale also shared his wonderful story about his friend, Aaron S. Witener, who had built an Ultradyne L2 kit, and had sent a letter with his logs of the stations the radio received to Phenix Radio which made an ad from them. Radio Collector Steve Rosenfeld, and Tube Lore author Ludwell Sibley gave many hours of their time thumbing through vintage radio magazines searching for articles and ad copy from the 1920's. I must say thank you to the late D.H. Moore who, like me, had great interest in Robert Lacault, and his Sketchbooks, due to their inaccuracies became the driving force for me to pursue this project. Last, I thank Robert Van Ghele, a man who served in the French Resistance during World War Two, and is not just a hero to his countrymen, but also to me. Robert did the research in France and was able to access Robert Lacault's birth and military records. Without his help this project would have never been completed.

About The Author

David L. Willenborg, N3UX was born and raised in St. Mary's County, Maryland. After graduation from Great Mills High School, he joined the U.S. Navy. Upon completing his required electronics training and graduating from Basic Submarine School he was assigned to the diesel submarine USS Grayback (SS-574). While on Grayback, he successfully qualified in submarines, and was responsible for operating, and maintaining the sub's MK106 Fire Control system. In 1984, the Grayback was decommissioned, and David was transferred to the nuclear powered fast attack submarine USS Shark (SSN-591). He served as the Fire Control Leading Petty Officer until he was transferred to the Naval Radio Receiving Facility, Kami Seya, Japan. After a two year

duty assignment, he was transferred to Norfolk, to finish 10 years of service aboard the Los Angeles class fast attack submarine USS Memphis (SSN-691). Returning home, David found employment at the Patuxent River Naval Air Station, first as a defense contractor, and now as a navy civilian employee.

David's interest in electronics and antique radios began as a child. His collection includes early superheterodynes, communication receivers, large tube count consoles, and a wide variety of plastic table radios. David's interest with Robert Lacault began when he purchased and restored an Ultradyne L-2 in the early 1990's. Since then his interest in 1920 kit radios has grown. He holds an amateur radio Extra Class License, with the call of N3UX.

David has been active in his community and served on the Maryland Republican Central Committee, and as the Republican Party Chairman for St. Mary's County. He is a member of the Mid-Atlantic Radio Club, Southern Maryland Mustang Club, Veterans of Foreign Wars, and the American Legion.

David Willenborg

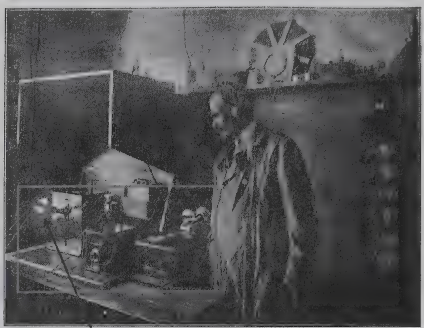
Lee de Forest and the Invention of Sound Movies, 1918-1926

©2013 Mike Adams

Abstract

Lee de Forest was one of the most influential 20th century inventors. As a Yale science student he had studied the work of Hertz, Edison, Poulsen, and Bell, and he understood the practical applications of Marconi's wireless. By 1906 he had patented his signature invention, the three-element vacuum tube he called the "Audion." In 1907 he broadcast music experimentally in New York, using a radiotelephone of his own design. Beginning in 1918 he developed and patented a system of writing sound on motion picture film for synchronized talking pictures. Between 1920 and 1926 he worked with fellow inventor Theodore Case to develop the Phonofilm system of variable density recording. For all future systems of entertainment delivery the de Forest tube was the key as it allowed amplification of audio over loudspeakers, thus making it possible for families to enjoy radio together and audiences to experience sound movies.

Lee de Forest entered the twentieth century with a world class education and ideas about inventions for wireless and radio. By 1906 he had patented his signature invention, the three-element vacuum tube he called the "Audion." By 1907 he was broadcasting programs of music using an arc transmitter and his tube as a detector/receiver. The significant difference between de Forest and all other wireless and electrical inventors was audio and his application and promotion of it which popularized radio and the talking motion picture.



Pig. 1: An early broadcaster. De Forest sent music by radiotelephone in 1907 as documented in this *New York Times* photograph. Most of the pieces of his radiotelephone were from the 19th century, the arc of Poulsen, the phonograph of Edison, the carbon telephone transmitter of Bell. The only new piece of this device was the de Forest Audion, used as a detector of audio.

Beginning in 1918 he conceived and patented a system of writing sound on motion picture film for synchronized talking pictures. Between 1920 and 1926 he worked with fellow inventor Theodore Case to develop a system of variable density recording, writing sound on film using modulated light. De Forest made hundreds of short films and screened them in theaters as "short subjects." De Forest and Case ended up in court, with neither the winner. But for all subsequent sound systems for motion pictures, the de Forest tube was the key as it allowed amplification of audio using loudspeakers which made it possible for audiences to experience talking pictures. In 1960 de Forest received an Oscar for his sound-on-film contributions.

In my de Forest research I collected thousands of pages of documents, many of them primary sources, and from this assemblage I wrote the book: *Lee de Forest, King of Radio, Television, and Film*, Springer Science 2012. This article focuses on the de Forest invention of sound-on-film, 1918-1926, patented and practiced as Phonofilm. It also shows the evolution of his Audion as an amplifier and oscillator of radio, and how de Forest combined these uses for optical sound-on-film. Lee de Forest improved upon the science of the 19th century to help create the mass media of the 20th century.

The Education of a Scholar

Born in the Midwest in 1873, Lee de Forest had by 1899 earned a Ph.D. in physics and electricity from the Sheffield Scientific School at Yale University. In an 1897 college notebook, de Forest drew a schematic diagram of an arc modulated by a telephone microphone, and next to it wrote: "Talking Ark, like

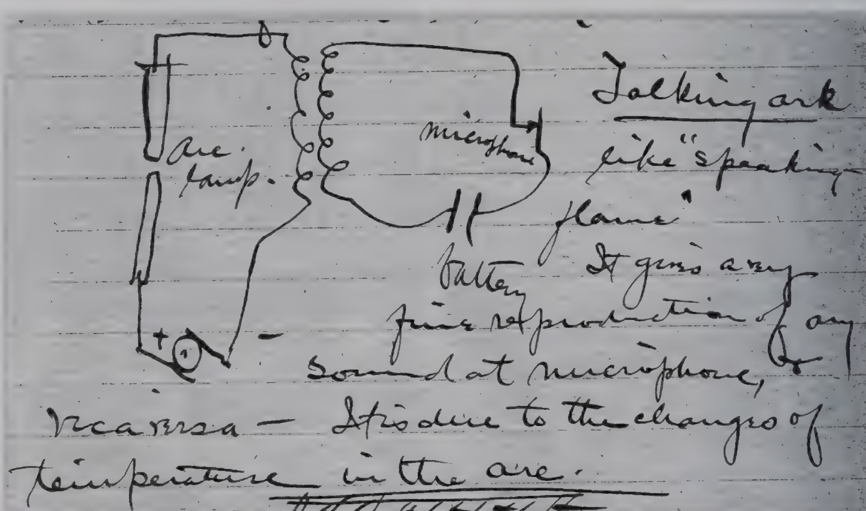
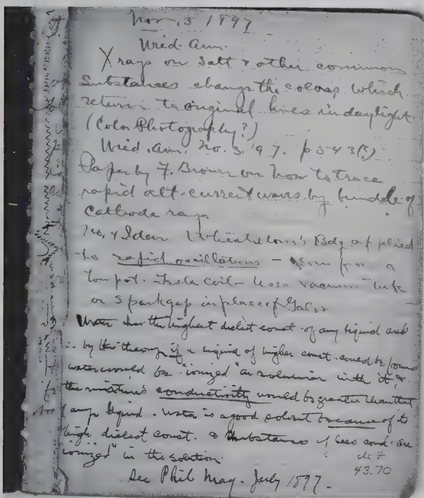


Fig. 2: A portion of a page from his college notebook which shows de Forest's fascination with the arc. He graduated with honors from Yale. *Perham Collection, History San Jose.*

'speaking flame.' It gives a fine reproduction of any sound at microphone." (1) As an inventor he will begin each project with this "speaking flame," using it as a talisman. It will be his inspiration for his first wireless detector, his vacuum tube, his radiotelephone transmitter, and his method of writing sound on film.



Nov. 3 1897

Scied. Am.

X rays on salt & other common substances change the colors which return to original hues in daylight (Color Photography?)

Scied. Am. No. 3. '97. p 543(?)

Paper by F. Braun on how to trace rapid alt. current waves by bundle of Cathode rays.

[illegible] Idea [illegible] applied to rapid oscillations – [illegible] from a low pot. Tesla coil – [illegible] vacuum tube or sparkgap in place of Galv.

Water has the highest dielect. const. of any liquid and by the theory if a liquid of higher const. could be found water would be "ionized" in solution with it, & the mixture's conductivity would be greater than that of any liquid. Water is a good solvent because of its high dielect. const. & substances of less cond. are "ionized" in the solution.

43.70

See Phil Mag. July 1897.

Fig. 3: Another page from the collection of several dozen Yale notebooks, most titled "Electricity," this one dated 1897. De Forest was top in his class, and was asked to write for the Yale Science Journal as an undergraduate. *Perham Collection.*

Lee de Forest entered the new century with an educated person's understanding of the science of the nineteenth century. He understood the limitations of wet plate photography, the phonograph of Edison, and the Photophone of Bell. He read about Edison as he collaborated with Eastman for a flexible film base for moving pictures. He understood the limitations of acoustical recording on cylinder and disc, and he knew about the Photographophone of Ruhmer. As with all successful inventors de Forest always performed the literature search, and the evidence of this is seen in the notes he made in the margins of collected scientific articles.

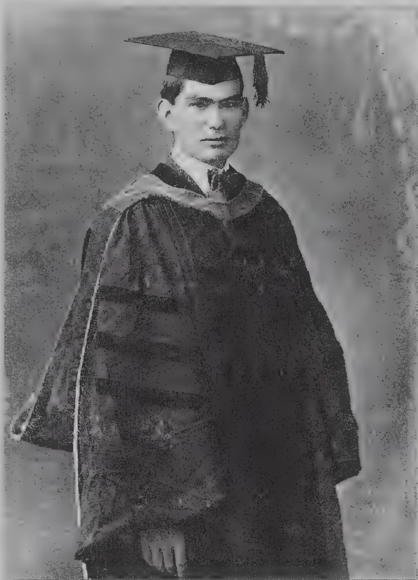


Fig 4: A Yale man. De Forest collected and read all of the scientific journals of his era, and made notes for possible patents that he might develop. This is part of the scientific method practiced by all successful inventors. *Perham Collection, History San Jose.*

The Importance of the Audion

The best example of how de Forest the inventor worked is found in the creation of his signature invention, the three element vacuum tube he called the Audion. The tube of de Forest can be traced back to Thomas Edison and his 1880 patent on what he called the "Edison Effect." (2) Edison's light bulb,

while it revolutionized civilization, did have one annoying drawback. Edison noticed that as the bulb burned and aged, its filament would add a black carbon deposit to the inside of the bulb, gradually building up and greatly reducing the light output. Edison experimented with the addition of a plate to "carry off" the electrons. He measured the direction of the current flow, observing that it moves from filament to plate. He discovered the principal of thermionic emission. He had created a "rectifier" but seeing no commercial value he put it aside. Former Edison UK employee Ambrose Fleming knew about the Edison Effect and by 1905 he had received a patent for a vacuum tube diode detector. (3) Then an employee of Marconi Wireless, Fleming believes he has found a better detector of wireless dots and dashes. In his diode patent, he has placed a galvanometer between the plate and filament to indicate the presence of code. It is a visual detector. The operator "sees" the code.

In one of the most significant events in the invention of electronic media, Lee de Forest reviewed the Fleming patent and made a small but very important change, one that reverberated for decades. In his patent a year later, 1906, called "Oscillation Responsive Device," (4) de Forest has cleverly substituted a second battery, called a "B" battery, and earphones in place of the meter. While he positioned his version of the Fleming diode as a device for listening to code, he had opened the first major door to audio. A year later he added the third element to his tube, the grid, and now his device is poised to be a receiver of voice over radio, and an amplifier which will later allow radios to speak loudly for family consumption. Of major importance, a tube that amplifies sound will add the missing link to future decades of experimentation of all versions of talking pictures, both sound-on-film and disc.

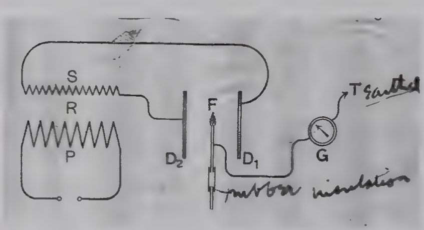


Fig. 5: Edison notes that electrons flow one way to a plate inserted into a light bulb and Fleming patents his version of it as a diode rectifier that detects wireless and indicates it using a meter.

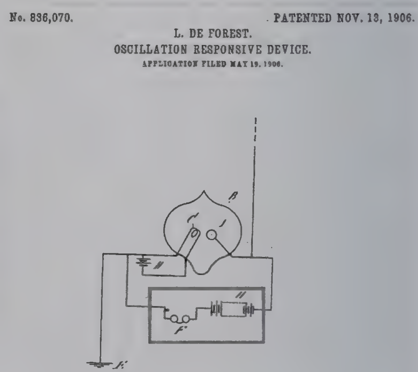


Fig. 6: A small but very important difference: de Forest's version of the Fleming Valve substitutes a "B" battery and headphone for the meter, moving the detector from visual to audio.

Sound Film Sputters and Dies

The years between 1890 and 1915 were the formative ones for the silent film. An industry emerged as technical investigation gave way to art. By 1915 film would find its visual language as it had moved from the experimental recording of events to storytelling using the shot, camera movement, and editing. As the public embraced the new media, the simple films of Edison and Porter gave way to the more expressive work of directors like D.W. Griffith. The motion picture began as 19th century science and became the first 20th century art form.

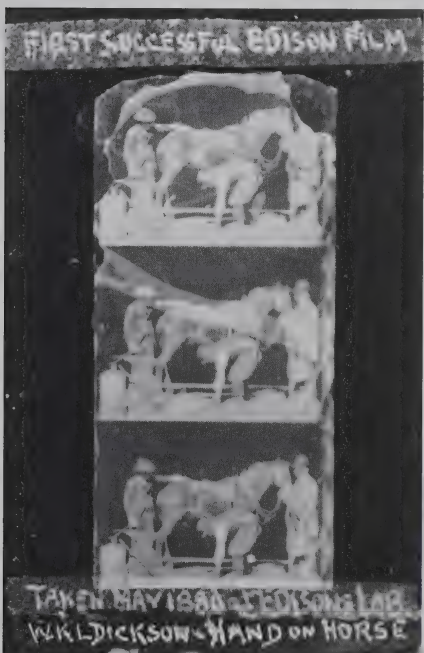


Fig. 7: A frame from an early Edison silent film, from the *Seaver Center, Los Angeles County Museum of Natural History*

Some experimenters believed that the addition of synchronized audio would make the film more real. It could be done as Edison employee W.K.L. Dickson proved in 1894 with a recently-discovered 15 second film of a man playing a violin into a large phonograph horn accompanied by Edison employees dancing. It showed how picture and sound could be synchronized, but it would be labor intensive in playback as operators would have to continuously speed up and slow down the film to match the audio. Another problem with film-phonograph sync sound was the length of recording time. With the cylinder and later the 78 rpm disc, there was a maximum plying time of 3-5 minutes, while even the shortest "one-reeler" film was 10-12 minutes. This system was abandoned early although it would make an important return visit in 1926.

Fig. 8: A frame of an Edison experimental sound film by assistant W.K.L.Dickson, 1894, restored by the *Library of Congress.*

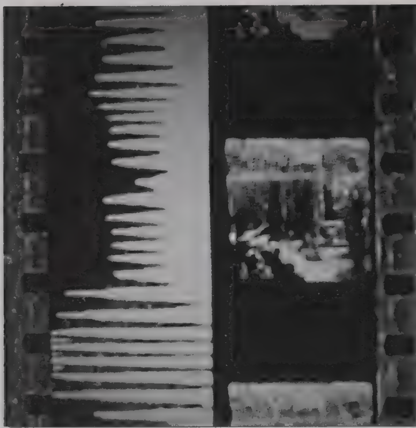


Fig. 9: A frame from one of the first optical sound on film experiments by Eugene Lauste.

There were several notable 19th century experiments in optical recording. The patent of the Bell brothers and Tainter for their Photophone describes the sending of voice without wires using a modulated arc at the transmitter and a selenium cell and earphone for a receiver. Early radiotelephone. (5) But also in their 1886 patent, "Transmitting and Recording Sounds by Radiant Energy," they added, "This invention relates to a new method of and apparatus for producing a photographic record of such vibrations." (6) This is likely the first known reference to writing with light on photographic media, although this was before a practical flexible film base and transport were widely available. A few years later German inventor Ernst Ruhmer developed a complete system for writing what appears to be a variable density sound track on 35 mm film using an oscillating arc modulated by a carbon telephone microphone and battery. For playback a selenium cell and earphone were used. His device was the Photographophone and it was described and illustrated in his book. (7)

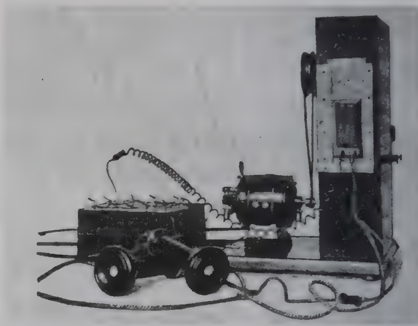


Fig. 10: One image from the Ruhmer Photographophone as illustrated in his book

Eugene Lauste in 1912 had developed a system for sound-on-film using a variation of a light valve, a galvanometer that would be used decades later for a variable area recording system. (8) As with Ruhmer years earlier, the Lauste version of sound-on-film used a carbon microphone and the insensitive selenium cell and earphone for reproduction. De Forest in 1913 was hired to develop a system for synchronized film sound, this time using the Poulsen wire recorder, the Tetragrammaphone. The advantage of wire as a recording medium was that the sound track could be much longer than the disc of Edison, but the problems of effective synchronization remained and the quality of recordings on wire was not good. Even Edison tried one more time in 1912 to present his version of a talkie using his phonograph. Apparently the

phonograph was behind the screen, and a long steel cable connected it to the projector motor for mechanical synchronization. Again, a labor intensive method easily requiring more than one person. This final Edison attempt failed.

By 1918 de Forest understood the problems of inventing a system of synchronized sound for motion pictures. He looked at the current technology of the microphone, still the carbon telephone transmitter of 19th century Bell design. It would never be sensitive enough to record sound well, because the performers would have to be just inches away from this type of microphone. De Forest also understood the synchronization and length of disc problems when using a phonograph-based system. He was also aware that the playback technology of the selenium cell used by Bell, Ruhmer and Lauste was barely good enough to power earphones. As was his inventing method, he had done the research and knew the problems that needed to be solved. And perhaps more importantly, having earlier sold his Audion amplifier patents to A.T.&T., he was looking for a new and profitable and patentable use for his tube. He will try the talkies.

De Forest Defines the Talkies

Lee de Forest believed that he possessed and understood the one important piece of technology that would gradually lead to a successful sound-on-film process, and that was his Audion vacuum tube. So on a single piece of paper dated October, 1918, de Forest described his version of a variable density recording and playback process for talking motion pictures. (9) He titled this handwritten page of notes, "3 methods for photographing sound waves on film for talking motion pictures." (10) Not surprisingly, his first method was "use the 'speaking flame.'" (11) His second method, "a very short, fine filament incandescent lamp – superimpose voice currents on the d.c. lighting current – gas filled lamp," and his third, "use 'glow tube light' – glass bulb filled with gas, e.g., hydrogen, helium, nitrogen, oxygen, or mercury. Electrodes of plate excited by high-frequency currents modulated by voice, exactly as in radiotelephony." (12)

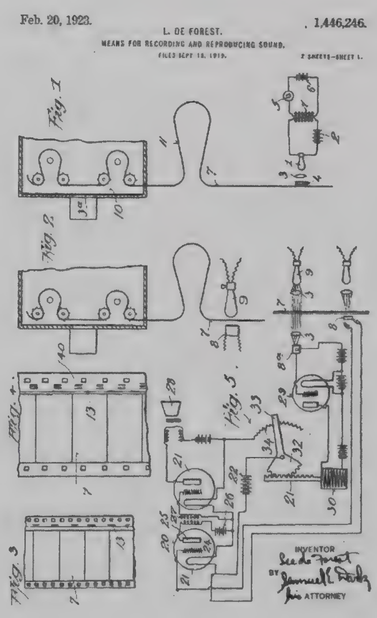


Fig. 11: In this collection, the 1918 drawings show how the triode is used to write sound on film, and the patent that resulted was filed in 1919. *Perham Collection.*

He would use these latter two methods to begin his experiments. The most significant part of this one page description was his use of his triode vacuum tube to amplify the microphone well enough to record a sound track through a "fine slit onto moving film." (13)

Less than a year later his drawing becomes the basis of a patent filed in September, 1919 called "Means for Recording and Reproducing Sound." (14) In this patent de Forest is able to combine his knowledge of his Audion tube as an amplifier of audio and as an oscillator/transmitter for practical radio, and directly apply both toward sound-on-film. This marks a major difference between the earlier Edison-Bell-Ruhmer-Lauste experiments and a system that will be good enough to satisfy public audiences. In this filing he has combined his experience in the sciences of optics, chemistry, physics and acoustics and explained in detail an entire system saying, "a further object of the invention is to reproduce talking moving pictures from a single roll of film." (15) This is the first practical explanation of how the talkies might work. It begins an almost decade-long period of time when de Forest and others developed his and other versions of sound-on-film. Whether the industry would settle on variable density, variable area, or disc, it was de Forest and amplification that would allow it to happen.

Looking at the patent details, it shows a de Forest unsure of how his theories might yield practical success. In both his drawings and his text, he seems to be saying that methods two and three might give the best results. He begins with the simple incandescent lamp, "the light emanating from the lamp is recorded on the film, preferably in the nature of a minute ray obtained through a pin point aperture or focused by a point by a lens." (16) In an analysis of Figure 1 of the patent by Berkeley Physicist John Staples, "the (carbon) microphone (labeled 5) is excited by a battery (labeled 6) and the voice currents are transmitted through a transformer to a lamp. The important thing to notice here is there is also a battery (labeled 2) in series with the lamp in the secondary. The reason for this is that the illumination of the lamp wants to be increased on positive voice peaks and decreased on negative voice peaks. Therefore the lamp is set at an intermediate intensity, and is modulated up and down with the voice waveform." (17) For reproduction in the original patent, de Forest writes, "I have found that the best results when using a photoelectric cell of the Kuntz variety." (18) For playback he has progressed beyond the now-discredited selenium cell.

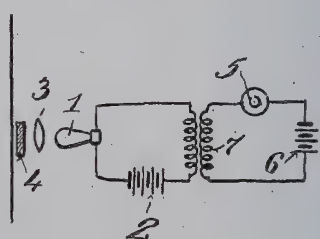


Fig. 12: Method 2 from the 1919 Phonofilm patent, Figure 1, a simple modulated incandescent bulb is shown at the right of the image.

Soon he finds that the incandescent glow lamp is unsatisfactory, its most problematic characteristic its thermal lag, as the tungsten filament brightens and dims. Within a year he puts all his energy into what he termed "method 3." And one year after this first patent filing he files another as a clarification. (19) In the drawing submitted for this patent, he shows just how his tube will be used. In the accompanying schematic (Figure 13) notice at the top of the drawing the speech amplifier triode, labeled "90" and at its input grid is a carbon microphone and battery coupled through a transformer. "Tube 60 is the oscillator. You can see that there is a path from the plate 61 to the grid 62 through the coil 64 which has the capacitors 66 across it, forming a tuned circuit. It produces a carrier wave oscillation that lights the lamp. The carrier frequency is determined primarily by the inductance of the transformer primary 64 and the two capacitors 66 across it. The audio from transformer 91 is impressed on the grid bias of the oscillator, which changes its amplitude. It is the composite signal, the amplitude-modulated signal that is coupled through transformer 64-65 to the glow tube." (20) This will prove to be the most successful system for recording a variable density audio track onto the film.

He begins a discussion in this patent of how the loop is used to smooth

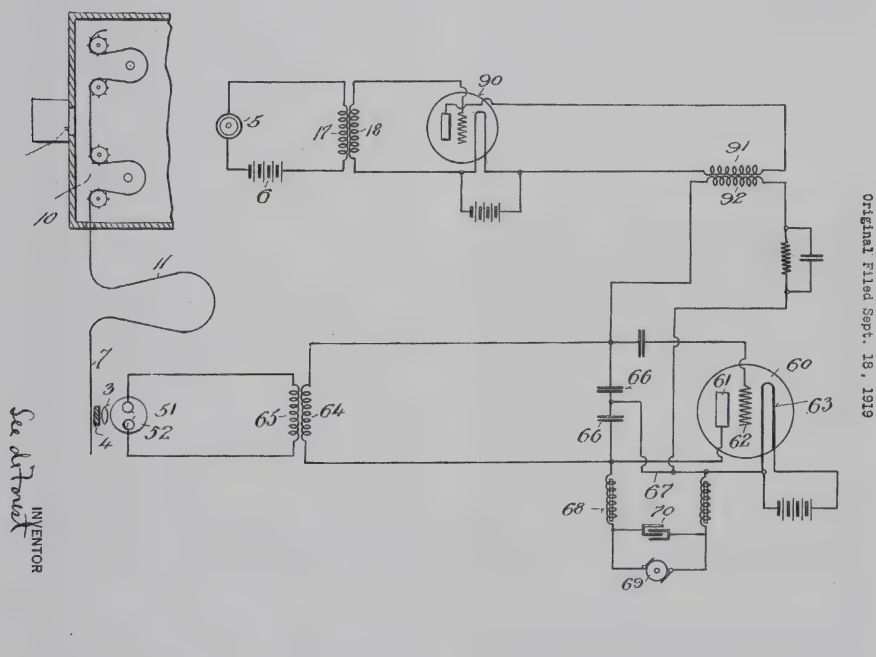
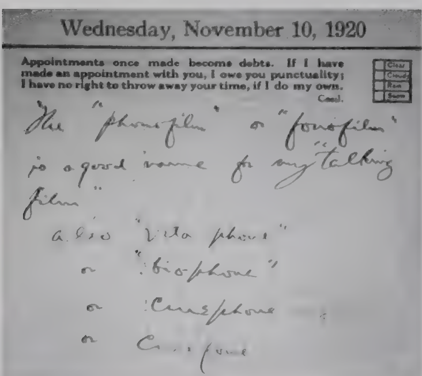


Fig. 13: This third method uses a high-frequency carrier for the audio, amplitude modulation, just like the 1915 de Forest AM radio transmitter using his "Oscillion" tube.

out the intermittent motion before the shutter, writing "and on one side of the loop I subject the film to the sound controlled light rays, the sound for controlling which is produced by the actors, musicians, or the like, which are being photographed." (21) In this early patent he does not specify a speed of travel for the film, but he does indicate that the sound in his system will be recorded before the picture. According to Ray Pointer, who was instrumental in transferring some of the original Phonofilms to videotape, "The average placement of Phonofilm soundtracks appears to have been 20 frames BEHIND the corresponding picture frame." (22) Experimentation continues daily throughout 1920 and 1921. There is a large body of laboratory notes and diary entries by de Forest during this beginning stage of invention. While his ideas and patent did appear fully-formed, they were probably more theory than practical possibility, as noted in his diary entry


Wednesday, November 10, 1920

Appointments once made become debts. If I have made an appointment with you, I owe you punctuality; I have no right to throw away your time, if I do my own. Cecil.

Clear
Cloudy
Rain
Snow

The "phonofilm" or "fonofilm" is a good name for any talking film

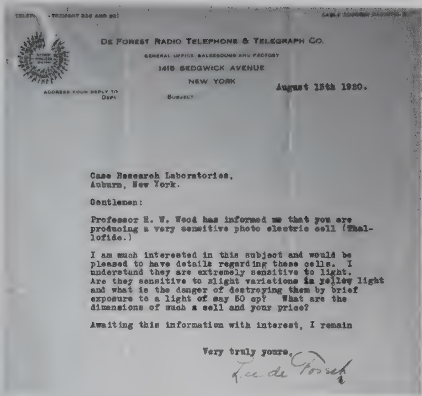
also "Vita phone"
or "bio-phone"
or "Casephone"
or C[illegible]fone

Fig. 14: Name that Invention. This de Forest diary page from November, 1920 shows how he was trying to find a name for his sound-on-film process. *Perham Collection.*

on August, 23rd, 1920: "On this day I made a photographic voice record on film with 'talking flame' – which actually spoke to me words which I had forgotten were there, 'one – two, three - - -nine, ten. August the twenty third." (23)

De Forest and Case Collaborate

It was two years following his theoretical concept of sound-on-film and patent filings that de Forest learned about the photocell work of young scientist and fellow Yale alumnus Theodore Case. He made this inquiry by mail: "Gentlemen, Professor R.W. Wood has informed me that you are producing a very sensitive photo electric cell (Thalofide)." (24) Case's background was in the development of photocells for clandestine infrared signaling during the just-concluded war, and he had not thought about film. The six year de Forest-Case collaboration, as evidenced in the Case papers, was largely a scientific one, as each inventor developed very small pieces of the system that would be known as Phonofilm. And while de Forest had the early ideas for recording sound-on-film, he needed Case because his cells were ideally-suited to write and reproduce the audio. Hundreds of letters were exchanged between the two scientists between 1920 and 1926, most of them technical discussions about how to improve their process.



DE FOREST RADIO TELEPHONE & TELEGRAPH CO.
GENERAL OFFICE SALESROOMS AND FACTORY
1415 SEDGWICK AVENUE
NEW YORK

ADDRESS YOUR REPLY TO DEPT SUBJECT

August 13th 1920.

Case Research Laboratories,
Auburn, New York.

Gentlemen:

Professor R. W. Wood has informed me that you are producing a very sensitive photo electric cell (Thallofide.)

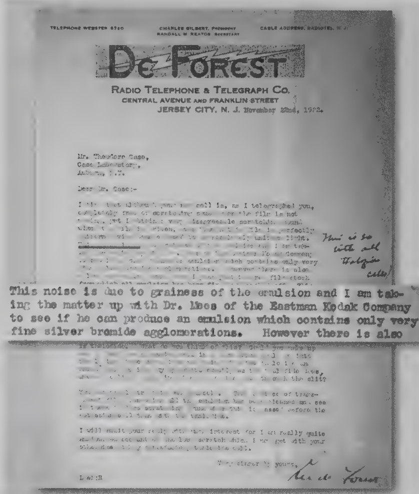
I am much interested in this subject and would be pleased to have details regarding these cells. I understand they are extremely sensitive to light. Are they sensitive to slight variations in yellow light and what is the danger of destroying them by brief exposure to a light of say 50 cp? What are the dimensions of such a cell and your price?

Awaiting this information with interest, I remain

Very truly yours,
Lee de Forest

Fig. 15: One of hundreds of letters exchanged between de Forest and Case , and his cells used for writing and reading the sound on film, *Case Museum, Auburn NY.*

As an example of the minutiae of invention found in their correspondence, in 1922 there was a rather long letter about how to eliminate a scratching sound on the sound track. Wrote de Forest: "This noise is due to graininess (sic) of the emulsion and I am taking the matter up with Dr. Mees of the Eastman Kodak Company to see if he can produce an emulsion which contains only very fine silver bromide agglomerations." (25) Another letter from Case: "I am sending down to you by the porter on tonight's sleeper the newest light which is very excellent. It may not look very bright to you but it is extremely rich in the violet. I think once you get this light right up to your slit you will have no trouble in getting pictures" (26) Both scientists were trying continuously to find the right combination of amplifier, cells, microphones, and film chemistry. The evidence shows that the two were in weekly communication between 1920 and 1925. Rather than any instant breakthrough the development of Phonofilm was slow, plodding, methodical, and in the beginning, mostly collegial.



TELEPHONE WEBSTER 5750 CHARLES GILBERT, PRESIDENT RANDALL W KEATOR SECRETARY CABLE ADDRESS, RADIOTEL, N. J.

DE FOREST
RADIO TELEPHONE & TELEGRAPH CO.
CENTRAL AVENUE AND FRANKLIN STREET
JERSEY CITY, N. J. November 22nd, 1922.

Mr. Theodore Case,
Case Laboratory,
Auburn, N.Y.

Dear Dr. Case:-

This noise is due to graininess of the emulsion and I am taking the matter up with Dr. Mees of the Eastman Kodak Company to see if he can produce an emulsion which contains only very fine silver bromide agglomerations. However there is also

Very sincerely yours,
Lee de Forest

Fig. 16: Scientific discovery at work. A sample of a letter between de Forest and Case; *Case papers.*

There were other technical problems to solve. The carbon microphone would be never be sensitive enough for high-quality recording, so de Forest begins experimentation on a microphone he calls the "Condenseraphone." (27) In the drawing he indicates a large Magnavox horn aimed at the plates of a condenser which is connected through a 650 volt source and amplified by a triode vacuum tube. De Forest also patents what he calls a "flame microphone." (28) Both of these microphones are an improvement over the 1880s carbon telephone

microphone, and both will find application in radio broadcasting as well as film. Years earlier he perfected his tube as an amplifier and oscillator. Now at the beginning of the decade of the 1920s de Forest is continuously contributing improvements to the important pieces of the twentieth century entertainment businesses.

There were also personal and business issues between de Forest and Case, and after a few years of the relationship problems began to surface. The first was one familiar to all who knew de Forest: sloppy business practices. In the very beginning Case contracted with de Forest on a lease arrangement for his cells, but de Forest and his company apparently could not pay on time or even keep accurate track of what was owed. The other issue that really bothered Case was that he was always in de Forest's shadow in matters of publicity. Case wanted his name on the marquee of the theatres showing these demonstration films. In a 1924 letter from Hugo Riesenfeld, director of the New York theatre showing the De Forest-Case films, he wrote this in response to the Case-credit-query: "You surely understand that all our publicity has been exclusively de Forest which we consider a valuable asset on account of the great popularity of radio." (29)

These two issues, lack of proper credit for his contributions, and lack of timely payment for his cells would eventually drive Case to work on his own version of Phonofilm. By 1924 be began to file patents for his improvements to the De Forest-Case system,

Fig 17: De Forest and Case fought over credit for the process, promotional flyers use the de Forest name and photograph, *Case papers.*

differences he believed would withstand patent challenges. (Case had attended Harvard Law after Yale) The other avenue for Case was a legal one, and he sought advice on how to collect money owed, and how to change the contractual arrangement with the de Forest Company for the rental of his cells. Ultimately Case wanted to completely sever the relationship, and this would soon lead to the courthouse. But in the beginning, the de Forest-Case relationship was mostly one of science, and at the New York offices of the newly created "De Forest Phonofilm Company," science was applied to art as short films were being made,

and theatres were being equipped with Phonofilm technology.

Promoting Phonofilm

While Case was the small town silent partner in science and the supplier of cells, de Forest had organized a public company for Phonofilm, sold stock, and began to make agreements with exhibitors to show his sound shorts before the main silent feature. This would ultimately place a great burden on the de Forest company to keep up with the demand for new films. De Forest understood what he had to do to make certain everyone knew about his successes – he wrote in science magazines, he gave speeches before professional organizations. And unlike many scientists of the era, he was always willing to sit down with members of the press. To promote his New York première in April 1923, he set the stage in his New York laboratory, he donned a white lab coat, and invited members of the press to watch his films. One week before his première at the New York Rivoli Theatre, he appeared before the New York Electrical Society to talk about Phonofilm and show the reel he had prepared for the premiere: "He admitted that the technique of building a talking drama for motion picture audiences was something which would require a long time to perfect and predicted that the silent drama would never be transformed in to a talking machine drama merely by superimposing dialogue on the present type of photoplay." (30) He tries to convince the attendees that he doesn't want to replace the silent film, but rather he is producing and showing "short subjects" of musical and vaudeville acts, prologue-like films that will go into theatres to screen before the main silent feature attraction.

The press reaction to the Rivoli event was mixed and not necessarily based on the technical quality of the de Forest system. The subject was changed from the one de Forest wanted, his invention of sound-on-film, to questions about why the industry would want to replace the venerable silent film with movies that talk. A Cleveland reporter in attendance writes, "New talking picture shown, but what of it? The invention, which is called the Phonofilm and which has been perfected by Dr. Lee de Forest, does all that is claimed for it. The action and the sounds synchronize perfectly – but what of it? The music sounds like ordinary phonograph music, which is very different from that of a symphony orchestra to put it mildly." (31) Still, de Forest will not give up.

The Importance of the SMPE

The major Hollywood/film industry professional-technical organization was and is today the Society of Motion Picture and Television Engineers, SMPTE, but until television was a reality they were just the SMPE. De Forest opened his first SMPE presentation in May, 1923 titled, "The Phonofilm," by giving credit to his influences from the 19th century: "Contrary to the popular idea, the history of attempts to record sound vibrations photographically is

not new." (32) De Forest believes that in order for Phonofilm to be successful he has to convince the film industry opinion leaders in the technical fraternity. De Forest wrote and presented three Phonofilm papers between 1923 and 1926 in person and for the *SMPE Transactions*. In this he was practically alone, as in the first half of the 1920s it is mostly de Forest who presents about sound for the movies. He is the first to describe before an audience of motion

The other of the three methods which I originally set out to develop, although far less simple and more difficult of attainment proved in the end the practical method for producing by electrical means light fluctuations of sufficient amplitude to be photographed in every *necessary* degree of intensity.

The light that I employed for this purpose was that of a gas-filled tube excited by high frequency current. It was not difficult to construct a gas-filled tube giving such a light when excited by a high frequency current from a small radio telephone transmitter. But it was no easy task to design such a tube which could, when connected to a small 5 or 10 watt high-frequency apparatus, generate a sufficient light to photograph all necessary variations of intensity upon a narrow strip of standard emulsion film, moving at the rate of 12 to 16 inches per second in front of a slit, one and one half, or two thousandths, of an inch wide.

Having now briefly outlined the general principles emp'oyed in develop ng the Phonofilm, a clearer understanding will be obtained if I outline briefly step by step the various instrumentalities employed from

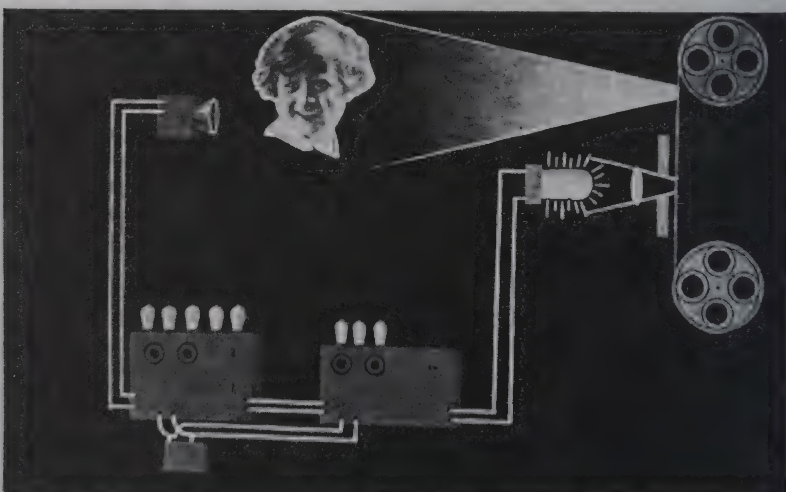


Fig. 18: A sample page of a de Forest presentation before the SMPE reproduced in *SMPE Transactions*, courtesy SMPTE

picture technical professionals "variable density" sound-on-film recording. He illustrates his SMPE talk with a collection of slides.

In this more technical description revealing how it works, he explains how it could not have been possible without his Audion both as an amplifier of weak signals, but also as an oscillator connected to the Photion tube to vary the intensity of the light. He compares his film recording system to a radio transmitter: "This oscillator is a form of the radiotelephone with which you are all more or less familiar. Connected to this high frequency output circuit is a gas-filled tube which I have called the 'Photion.' This tube glows at all times with a violet light which is highly actinic in quality. The intensity of this light increases around its normal brilliance in exact correspondence with the modulated high frequency energy of the oscillator. The light from the end of this tube is focused by means of a lens upon the very fine slit directly upon the emulsion side of the film." (33)

And in actual production? "For example, everyone must work in absolute silence, except the actors or musicians who are being actually recorded. This involves, of course, studios particularly designed for this work with every precaution taken against extraneous noises and interior echoes. The usual hammering, pounding and general bedlam which has heretofore distinguished the moving picture studio must be completely eliminated during a 'take.' A new type of moving picture director must be evolved, or if the old type is continued he must be thoroughly gagged, and learn to direct by signal and gesture only." (34) What he is doing, perhaps unknowingly, is threatening the familiar way of life of thousands of motion picture employees, not to mention making obsolete all the studios and equipment used in the very successful business of silent motion pictures. A member of the Society of Motion Picture Engineers would have to seriously consider all this and what it might mean to his or her livelihood. De Forest is the first to sound this alarm.

Still, interest by the Hollywood technical fraternity remained low and the use of synchronized sound in a film was still a curiosity. In the first half of the 1920s the SMPE featured only four papers on sound-on-film, and three of them were by Lee de Forest. The only non-de Forest paper was presented on the same stage immediately after the May 1923 de Forest reading. University of Illinois Professor J. Tykocinski Tykociner's paper was "Photographic Recording and Photoelectric Reproduction of Sound," a reprise of the same paper he had delivered on June 9, 1922 before the IEE, the Institute of Electrical Engineers. He is basically saying what de Forest had said before him, "The leading idea in the recording experiments was to modulate a source of photographically active radiations by means of telephonic currents in such a manner that the actinic (radiation that causes a chemical effect) rays concentrated upon a moving photosensitive film shall leave after development of the film a record of the variations of light

intensity." (35) His system, confined to his classroom laboratory, was an early example of a "light valve" and "variable area" recording.

Case and the Courtroom

The year 1926 will be the beginning of the end for the De Forest Phonofilm Company. The first Vitaphone release, "Don Juan" with John Barrymore, features sound effects of swordplay and music synchronized using the formerly discredited phonograph record, now with a much-improved electrical recording and playback system. It is a hit and Lee de Forest becomes ill when he learns the news: "Last week the flashing posters of Vitaphone gave me first a shock, like a blow. Why and how have we wasted the last two years?" (36) One year later "The Jazz Singer" would be released, and this would be the starting gun for the wholesale conversion from silent to sound.

Fig. 19: Warner Brothers theatre marquee advertises The Jazz Singer, *Case Museum*

Meanwhile, Theodore Case is tired of living in the inventing and publicity shadow of de Forest. In 1924 he begins to both make films and patent what he believes is a better version of the Phonofilm technology. Believing that the most important parts of the system, the Thalofide cell for playback and his AEO lamp to write on the film are his, he sells his process and patents to William Fox and they call it "Movietone." De Forest sues and sides are taken, exhibits and evidence are presented. The first big sound-on-film case of 1926 is "de Forest v. Fox-Case." The preparation of this case will take several years during which time the Hollywood film community will make sound pictures using a variety of systems, apparently oblivious to what is happening in the offices of the New York lawyers of de Forest and Case.

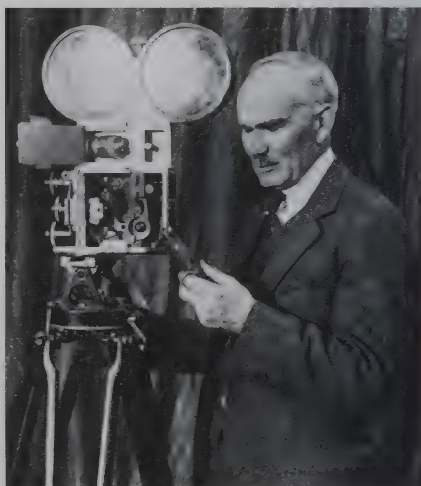


Fig. 20: De Forest with modified-for-sound Bell and Howell camera, *Case Museum*

What both parties in this suit really ending up presenting to the court can be summed up in this letter from Case to his attorney: "The idea of photographic sound-on-film and reproducing

it electrically had its inception long before Dr. de Forest entered the field. The idea first developed in this country in 1880 – 46 years ago. Since those early trials it has become more a question of producing suitable tools in the form of photo-electric cells, taking lights and reproducing apparatus to accomplish the results desired by the pioneers in the field" (37) De Forest submitted several books of evidence, also showing that the roots of sound-on-film could be traced back to Bell and Ruhmer. (38) After three years both sides agreed to a draw. In 1929, Fox settled with de Forest for $60,000 (worth about $800,000 in today's dollars) and de Forest agreed to drop the suit. This settlement went largely unnoticed by a movie industry rushing to convert their entire operation from silent to sound.

Perhaps one reason that Phonofilm failed to attract the attention of Hollywood was that de Forest the scientist was not de Forest the film maker. The silent film of the mid-1920s was a highly developed art that used the then mature language of film of the shot, camera movement and editing. A de Forest Phonofilm was typically a single establishing shot without camera movement or editing.

Oscar at Last

De Forest called the 1920s his lost decade, a ten year period in which he combined the best of 19th century technology and the lessons learned from his vacuum tube into what he believed would be his major accomplishment – the talkies. By 1930 he had sold the Phonofilm company and he would spend

Fig. 21: The Tale of Two Tunes. Film is a story-telling medium and it accomplishes this by using the language of film, like the establishing shot, the medium shot, the close up, etc. In these frames from two big band films from 1926, one de Forest, one Vitaphone, the top row filmed by de Forest uses a single long shot throughout the entire film. The lower one by Warner's uses close ups and medium shots to highlight the solos by the musicians. This language is what audiences were used to seeing in the silent films beginning about 1904. De Forest's films were boring science projects, not Hollywood movies.

the remainder of his long life, until 1961, trying to secure his legacy, telling his story to anyone who would listen, and generally reaping the rewards of a long and important career. In April, 1960 he was awarded an honorary Oscar: "Academy Honorary Award to Lee de Forest for his pioneering inventions which brought sound to the motion picture." (39) He was also in the first group of film and radio-television people to have their stars on the Hollywood Walk of Fame, his for film. According to the Hollywood Chamber of Commerce, his star was embedded into the sidewalk on Vine Street on February 9, 1960 with a very large group, done with little fanfare and there is no known visual record of this event. (40)

In the end Lee de Forest will be remembered for his signature invention of the vacuum tube, which made practical radio, television, and sound film a reality. Nevertheless, for inventor de Forest, the years between 1919 and 1930, were those in which he labored, saw fortune appear and then disappear, heard applause rise and then fall, finally to be mired in court battles, some won, some lost, most just faded to black.

Fig. 22: The de Forest Oscar, *Perham collection*

End Notes

1. Lee de Forest, Yale notebook collection, 1896-1899, Perham Collection, De Forest papers, History San Jose State (HSJ)
2. Thomas Edison, U.S. Patent 307,031, 1880
3. J.A. Fleming, "Instrument for converting alternating electric currents into continuous currents, U.S. Patent 803,684, Nov 7, 1905
4. Lee de Forest, U.S. Patent 836,070, Nov 13, 1906
5 – 6. A.G. and C.A Bell, Tainter, U. S. Patent 341,213, May, 1886
7. Ernst Ruhmer, *Wireless Telephony*, Crosby, Lockwood and Son, London, 1908
8. Edward Kellogg, "History of Sound Motion Pictures, part 1," SMPTE Journal, June 1955
9 – 13. Phonofilm notes, Lee de Forest, papers, Oct, 1918, Perham
14 – 16. de Forest patent 1,446,246, filed Sept. 18, 1919, issued Feb 20th, 1923
17. Author correspondence with Dr. John Staples, Lawrence Berkeley Lab, 2012
18. de Forest patent 1,446,246
19. Means for Recording and Reproducing Sound, filed Nov. 11, 1920, issued in 1924 as 1,482,119
20. Analysis by Staples, LB lab, 2012
21. de Forest patent 1,446,246
22. Author correspondence with Ray Pointer,

a film maker who participated in the transfer of the de Forest films
23. de Forest diary, Aug 23, 1920, Perham, de Forest papers
24. Letter, de Forest to Case, August, 1920, Case Papers, Auburn NY
25. Letter, November 23, 1922, de Forest to case, Case papers
26. Letter, Dec 22, 1922, Case to de Forest, Case papers
27. De Forest lab notes, Aug 3, 1920, Perham collection
28. *Radio News* July 1923
29. Letter from Hugo Riesenfeld to Phonofilm company manager Waddell, Feb 13, 1924, Case papers
30. *New York Times*, April 5, 1923
31. *Cleveland Plain Dealer*, April 22, 1923
32 - 34. *SMPE Transactions*, No. 16, May 1923
35. JT Tykociner, "Photographic Recording and Photoelectric Reproduction of Sound," *SMPE Transactions*, No. 16, May 1923
36. De Forest diary, July 25, 1926, de Forest papers
37. Case statement, re: suit by de Forest, Aug 6, 1926, Case Papers
38. From the two-volume de Forest court exhibit for his suit, *de Forest Phonofilm Corporation v. Fox Case Corporation*, 1929, a copy of which is in the Case Papers
39. This Oscar is part of the Perham de Forest papers, History San Jose. The author has copies of the original correspondence which led to the award, papers in the AMPAS Herrick Library
40. Author phone conversation with the office of the Hollywood Chamber of Commerce, the group in charge of the "Walk of Fame")

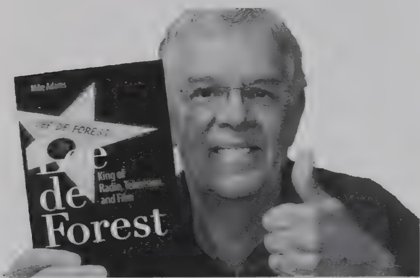
For a complete explanation of the significance of all the de Forest and Case primary source documents and papers, see Mike Adams, *Lee de Forest, King of Radio, Television, and Film*, Springer Science, NY, 2012

ABOUT THE AUTHOR

Mike Adams has been a radio personality and a film maker. Currently he is a professor of radio, television, and film at San Jose State University, where he has been a department chair and is now serving as the Associate Dean of the College of Humanities and the Arts. In addition to his work at San Jose State, Adams continues to teach classes at the Shanghai Theatre Academy School of Television and Film. As a researcher and writer of broadcast and early technology history, he created two award-winning documentaries for PBS, the Emmy-nominated "Radio Collector," and "Broadcasting's Forgotten Father." Mike is the Board Chair of the California Historical Radio Society. For his service to historical radio research and publication he received the AWA Houck Award, the SCARS President's Award, the TCA Stokes Award, the Ralph Batcher Award from the Radio Club of America, and he was named a CHRS History Fellow. He has had published numerous articles and four books, including *Charles Herrold, Inventor of Radio Broadcasting*, 2003, McFarland, and *Lee de Forest, King of Radio, Television, and Film*, Springer Science, 2012.

You can find more de Forest on the Web:

My de Forest Web: http://www.leedeforest.org
My de Forest Facebook: http://www.facebook.com/pages/Lee-de-Forest-King-of-Radio-Television-and-Film/144784125605950 (contains a dozen Phonofilms, photos and more of the story)



Mike Adams

Published by

THE ANTIQUE WIRELESS ASSOCIATION

PO Box 421, Bloomfield, NY 14469-0421

www.antiquewireless.org

Printed in Canada